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CR-159575 Vol. π



ACOUSTIC AND AERODYNAMIC PERFORMANCE INVESTIGATION OF INVESTED VELOCITY PROFILE COANNULAR PLUG NOZZLES

Comprehensive Data Report

VOLUME II

P.R. Knott J.T. Blozy

GENERAL ELECTRIC COMPANY

(NASA-CR-159575-Vol-2) ACCUSTIC AND

AERODYNAMIC PERFORMANCE INVESTIGATION OF
INVERTED VELOCITY PROFILE COANNULAR PLUG HC AD WE AD \
NOZZLES, COMPREHENSIVE DATA REPORT, VOLUME 2
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7.0 ACCUSTIC DATA COMPARATIVE PLOTS

7.1 INTRODUCTION

In the following sections data plots are presented which examine the noise characteristics of the coannular nozzle. The effect of changes in both the nozzle flow parameters (i.e., velocity, temperature, pressure ratio) and the coannular nozzle geometry are presented. All data are normalized except for PWL spectra and the first 10 points, which are comparisons with JENOTS data.

Unless otherwise specified, the following plots are presented for each study.

For full size (513 in.2) at the 2400-ft sideline:

1. PNL directivity, normalized

For model size (29.399 in.2) at the 40-ft arc:

- OASPL directivity, normalized
- 2. 1/3-octave band PWL spectra, unnormalized
- 3. 1/3-octave band SPL spectra at angles of 50° , 90° , 130° , and 140° to the inlet, normalized

The following normalization factors have been used in the plots:

1. PNL - 10 LOG(FT/F_{REF})

where:

PNL perceived noise level

FT total ideal thrust

 F_{REF} reference ideal thrust ($F_{REF} = 5130 \text{ lbf}$)

2. OASPL - A

where:

 $A = 10 LOG(AT/R^2) + 10 LOG(FT/(AT *F_{REF}))$

OASPL overall sound pressure level

AT total area

R distance

FT total ideal thrust

 \mathbf{F}_{REF} reference thrust/reference area ($\mathbf{F}_{REF} = 10 \text{ lbf/in.}^2$)

3. SPL - 10 LOG(A/R²) - 10 LOG(FT/(A*F_{REF}))

where:

SPL sound pressure level

A total area

R distance

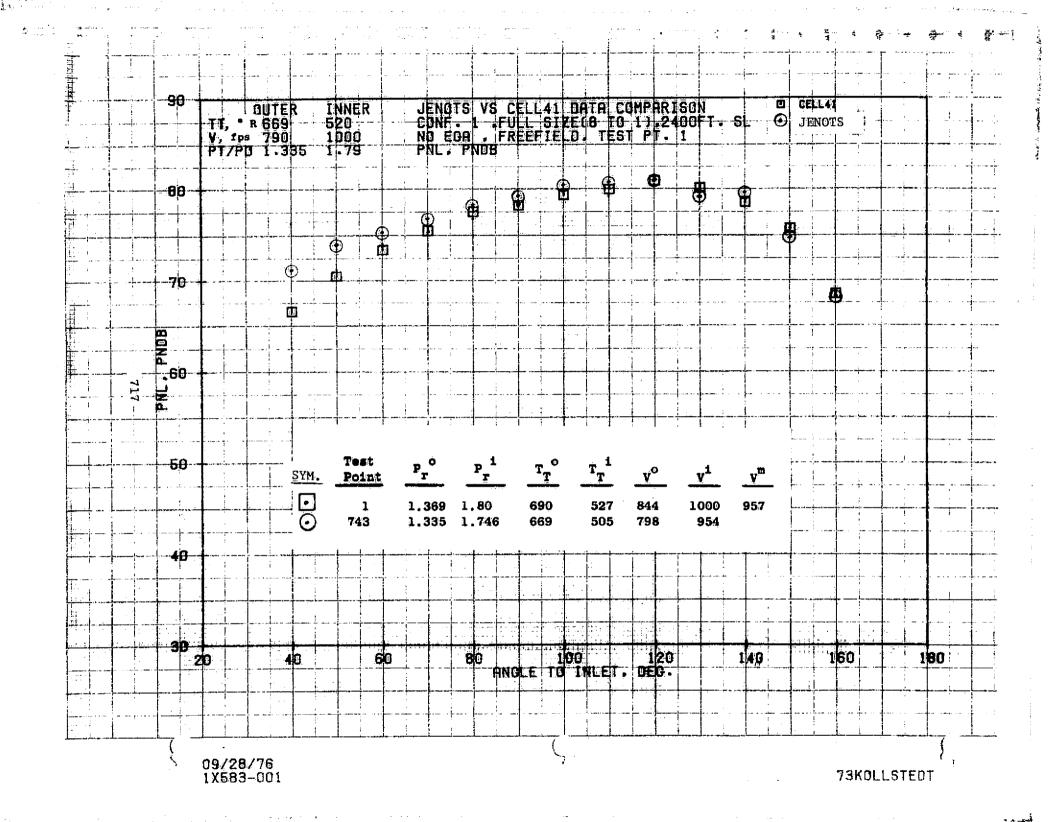
FT total ideal thrust

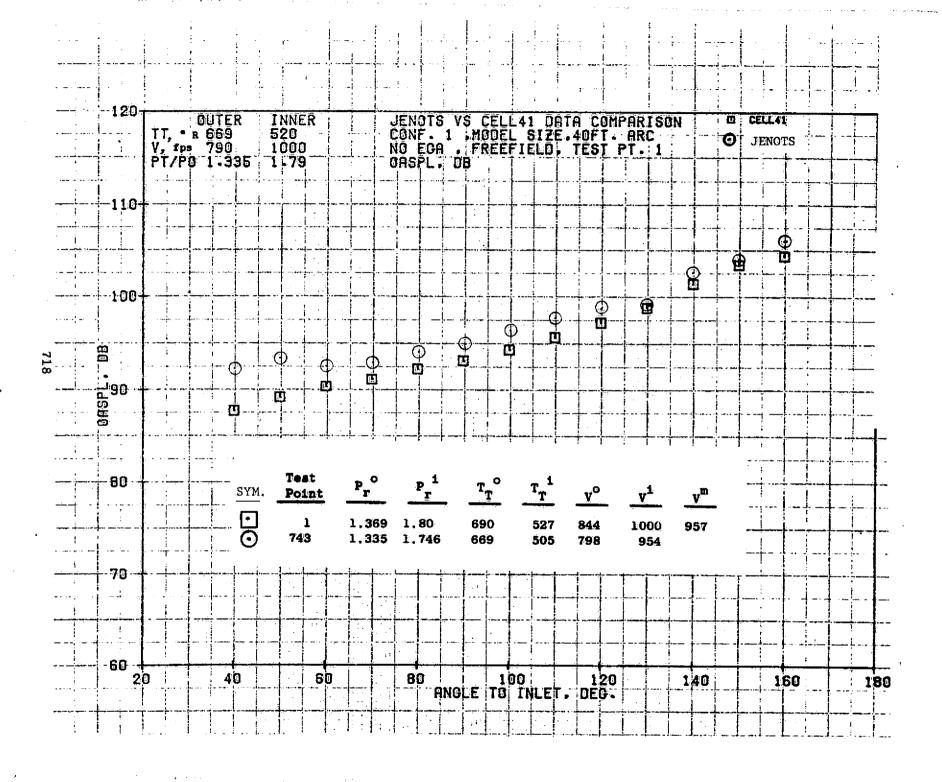
 F_{REF} reference thrust/reference area ($F_{REF} = 10 \text{ lbf/in.}^2$)

Only a presentation of the data is made in this report. Data analysis is addressed in the main final report. On each plot the measured flow conditions are shown for all data points in the comparison.

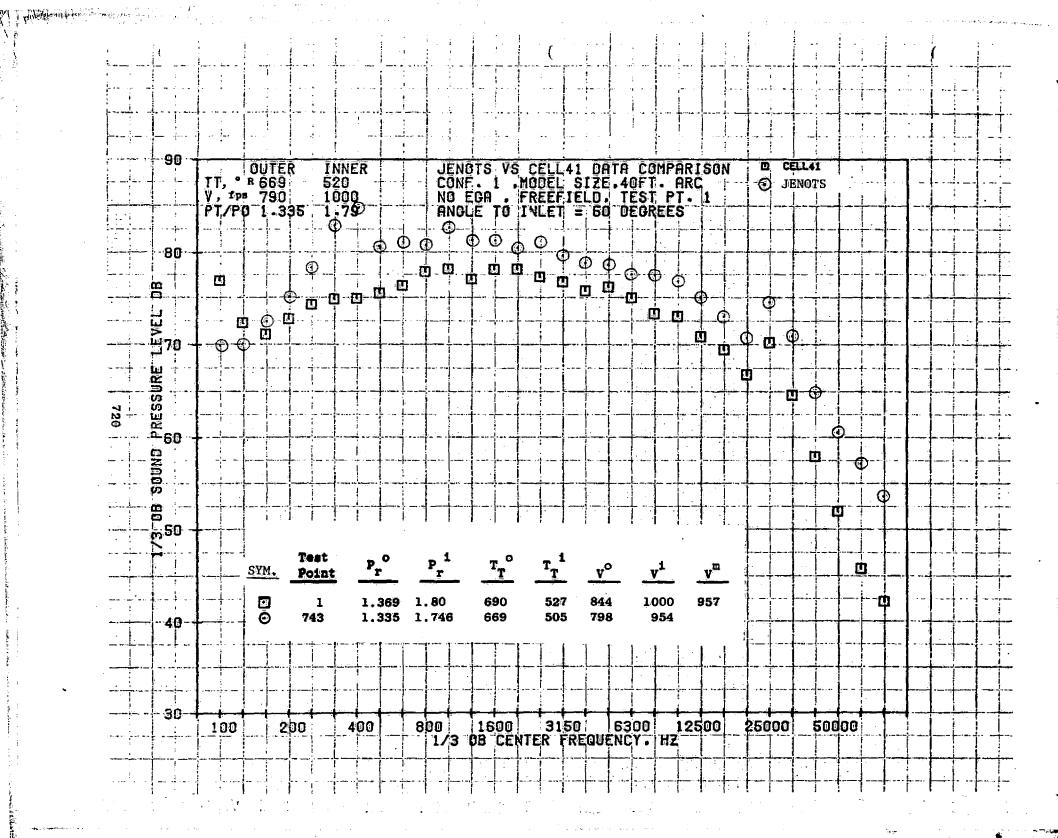
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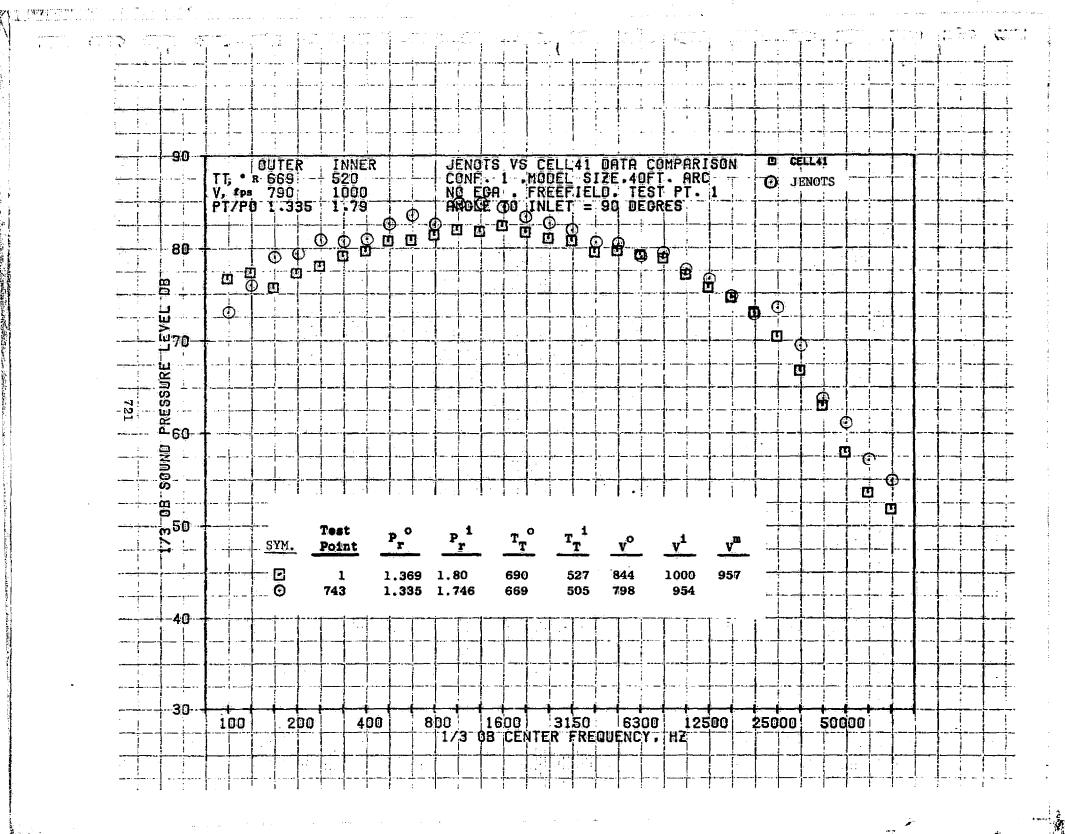
The purpose of this data analysis group is to compare data measured previously in the General Electric outdoor acoustic test site (JENOTS) with the acoustic measurements in the General Electric Anechoic Jet Noise Facility (Cell 41). Ten test points were chosen for this comparison. For these points the full-size comparison was made at 1812 in. 2 and both full-size and model-size data were not normalized since the test model was exactly the same in size and geometry. The JENOTS data was previously reported in NASA CR-135239.

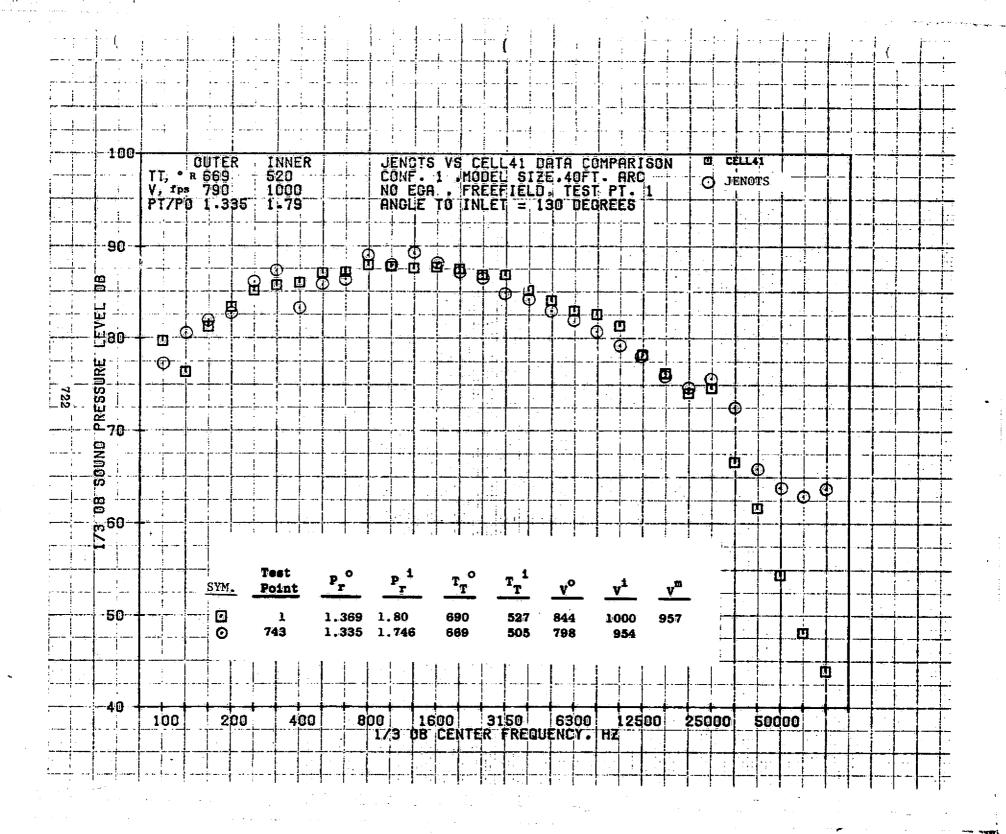


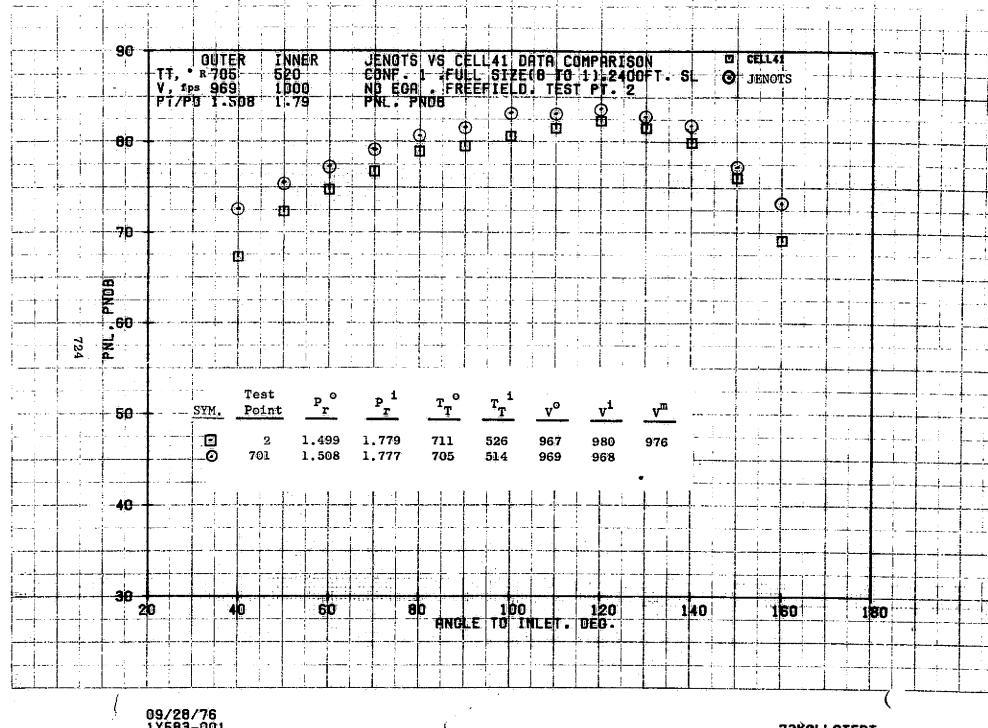


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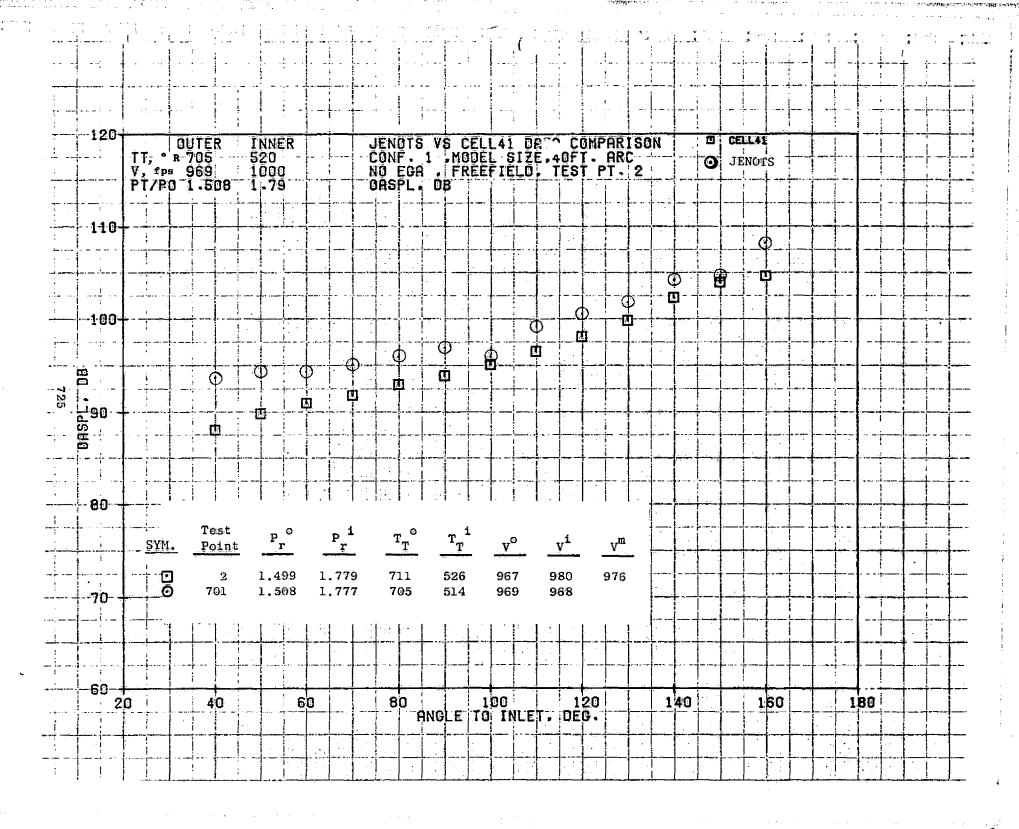


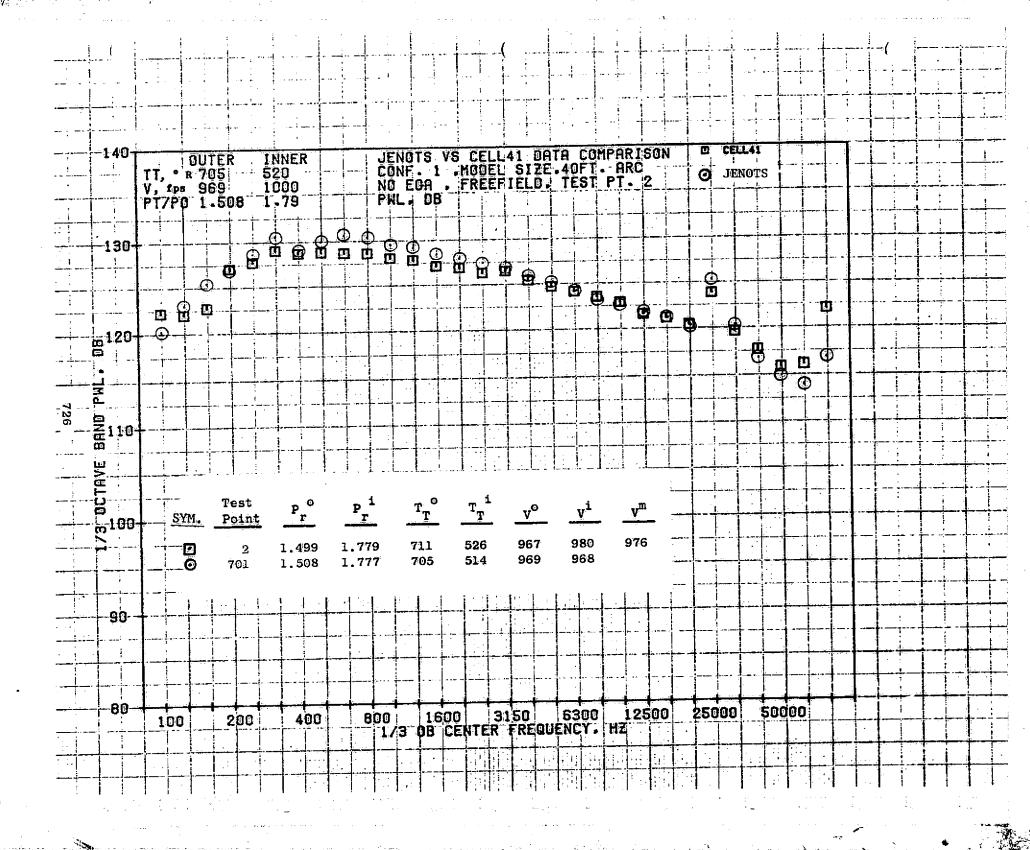


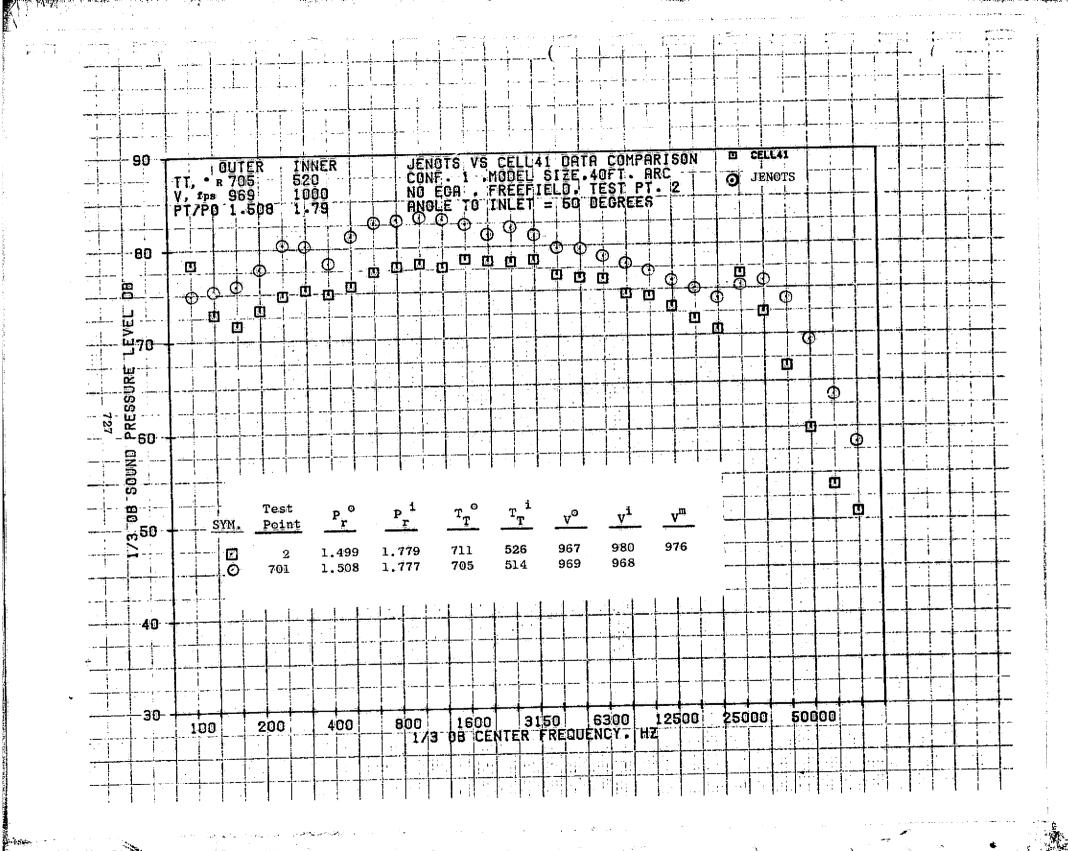


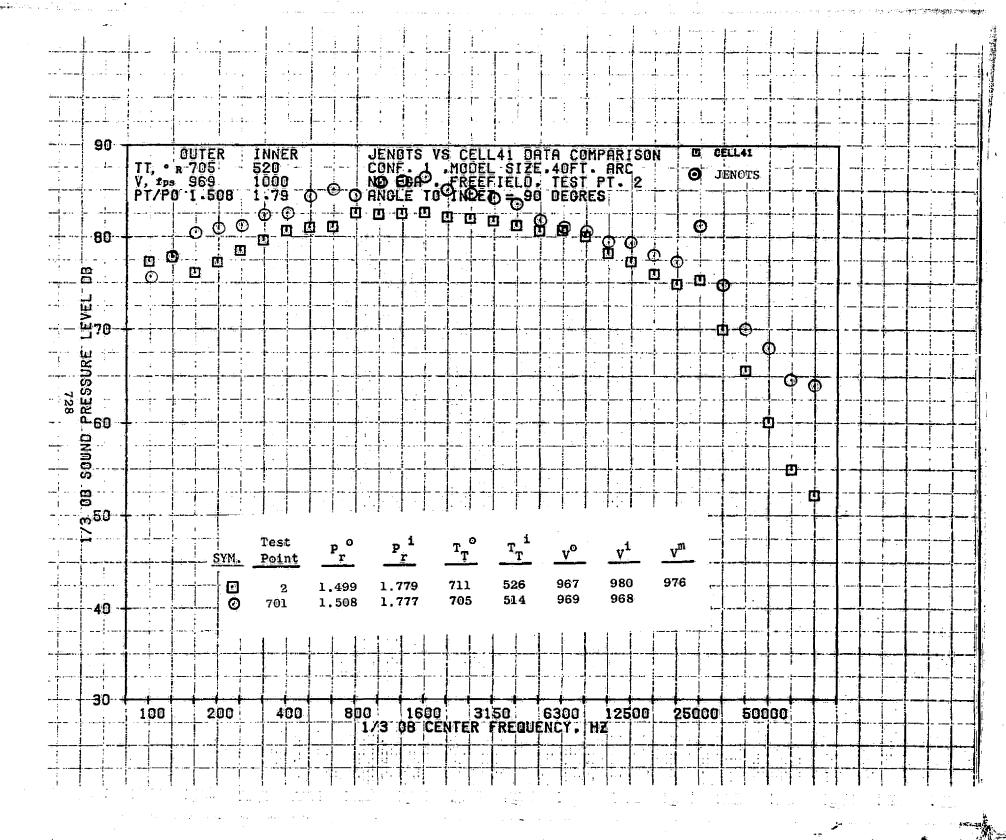
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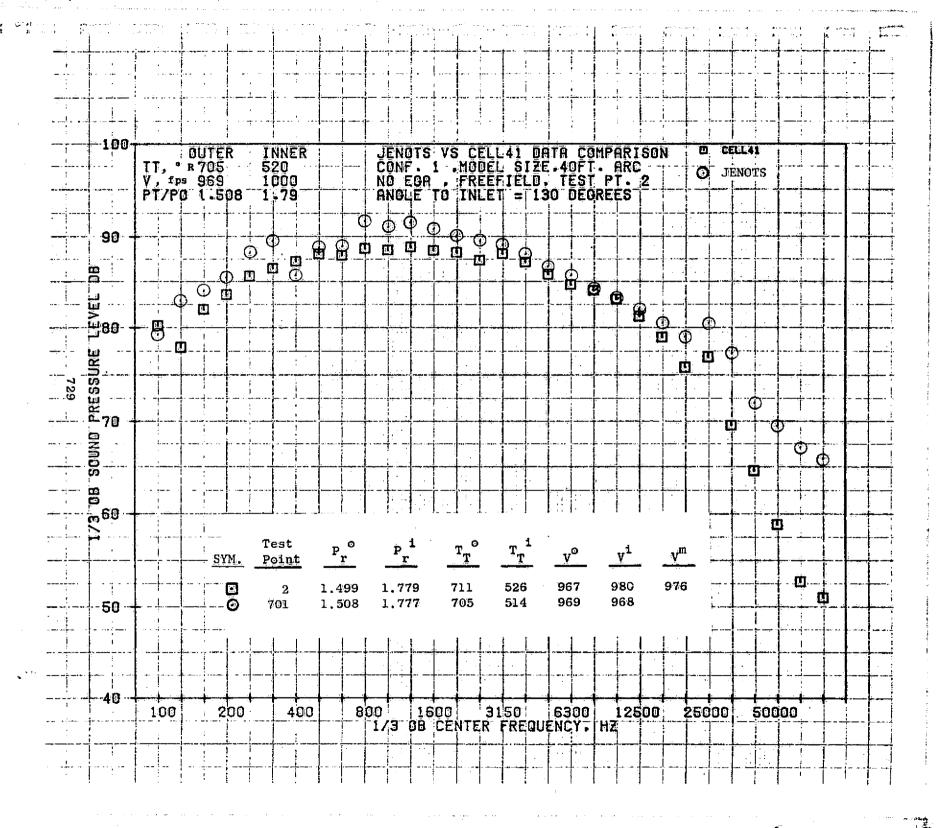
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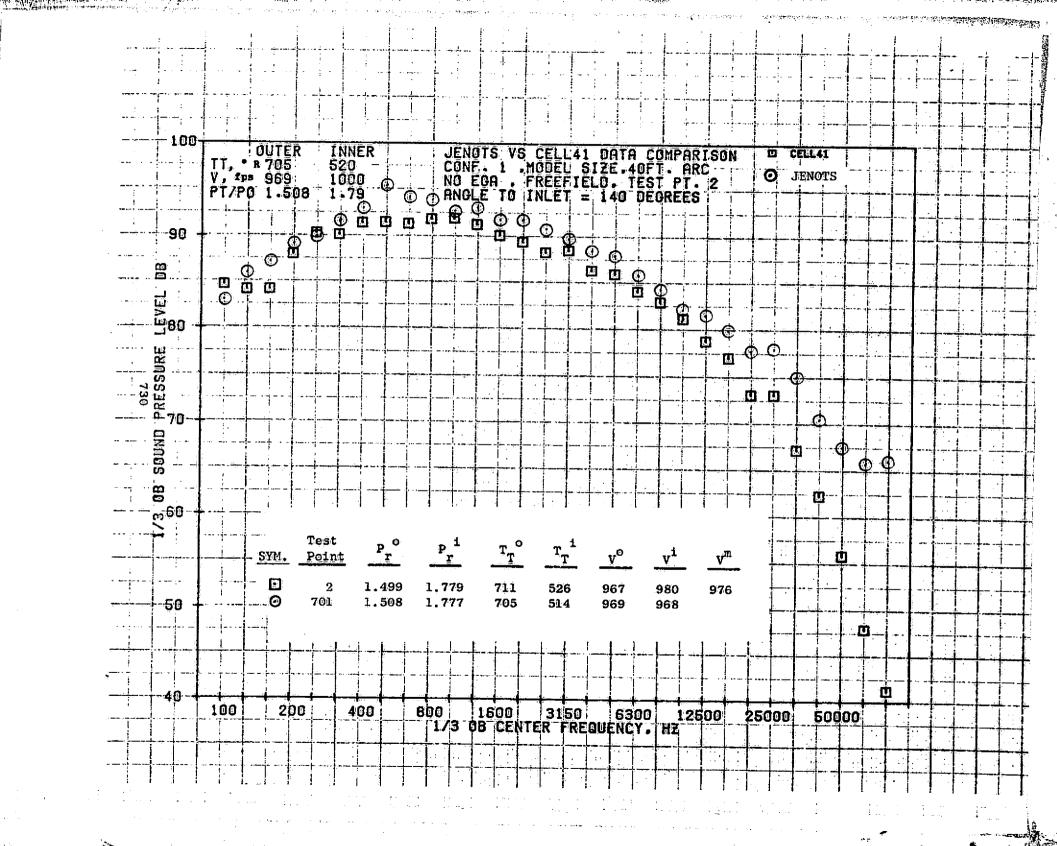


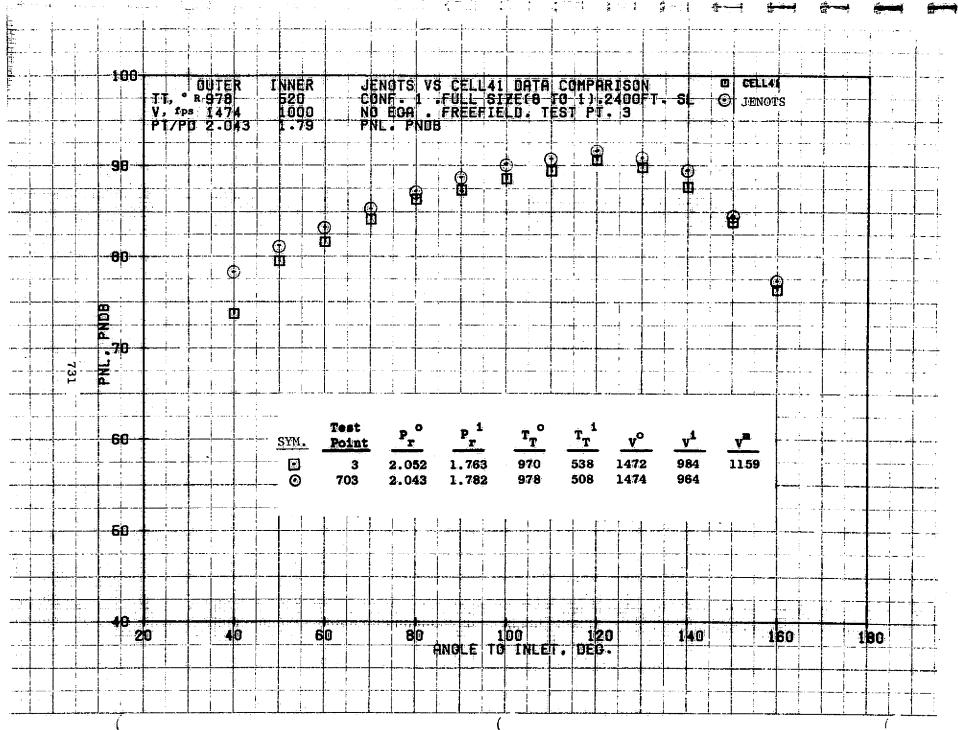






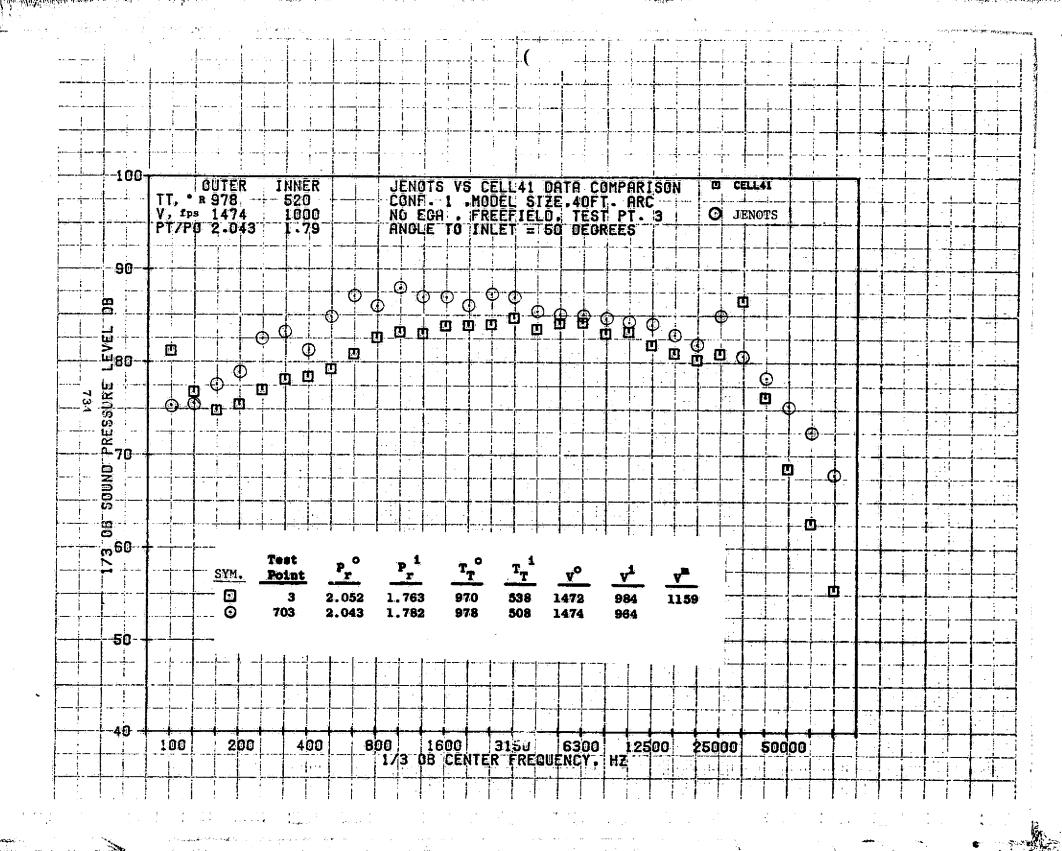


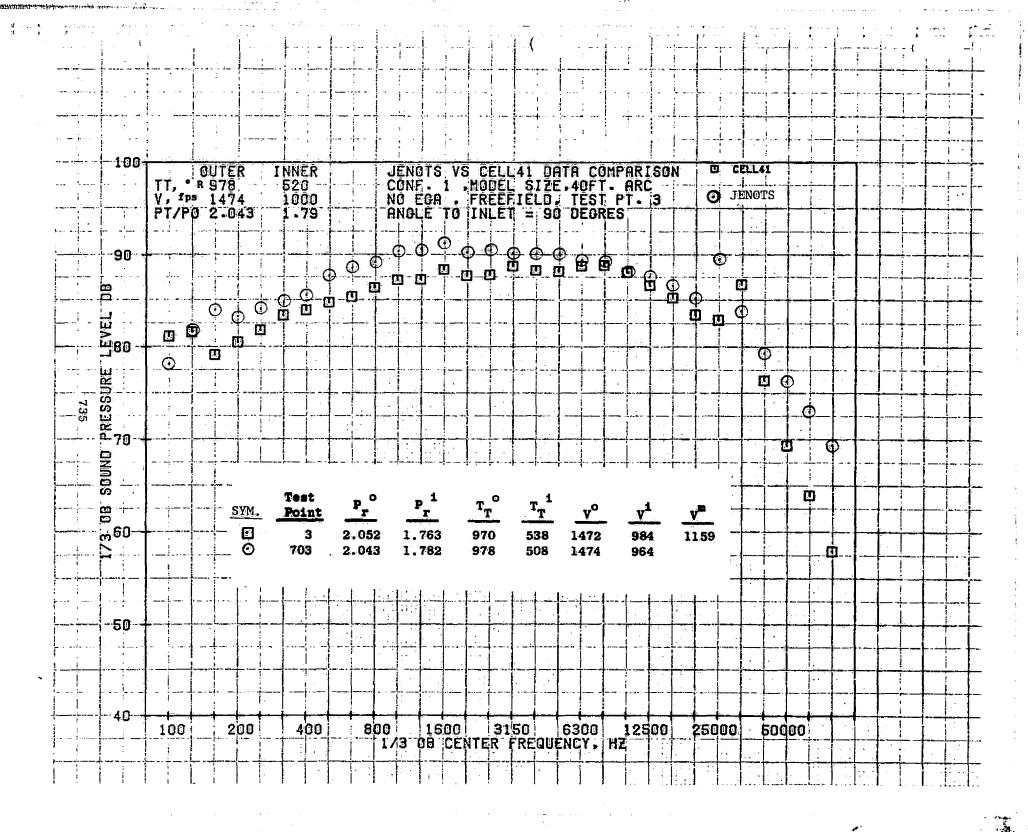


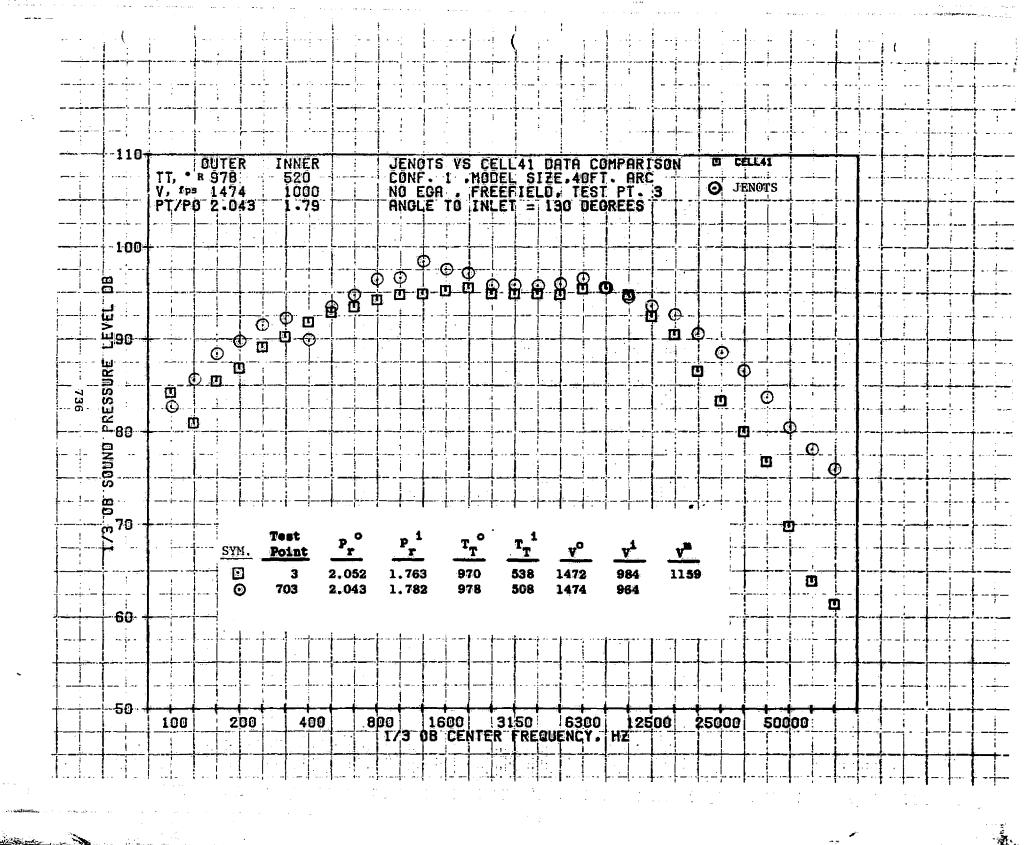


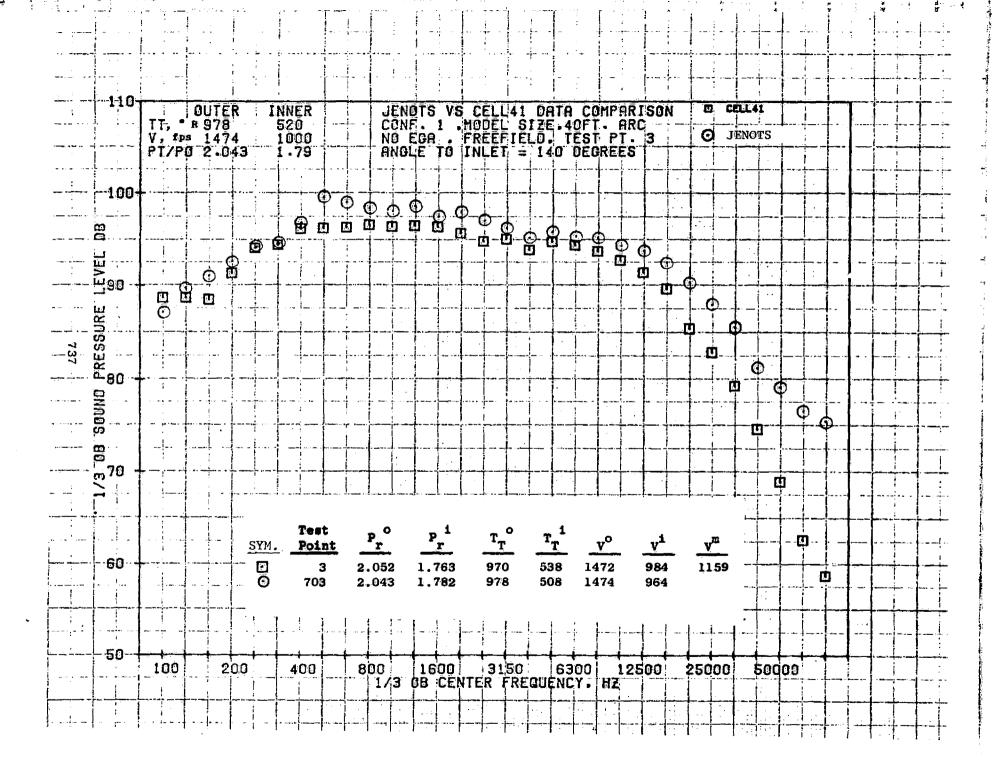
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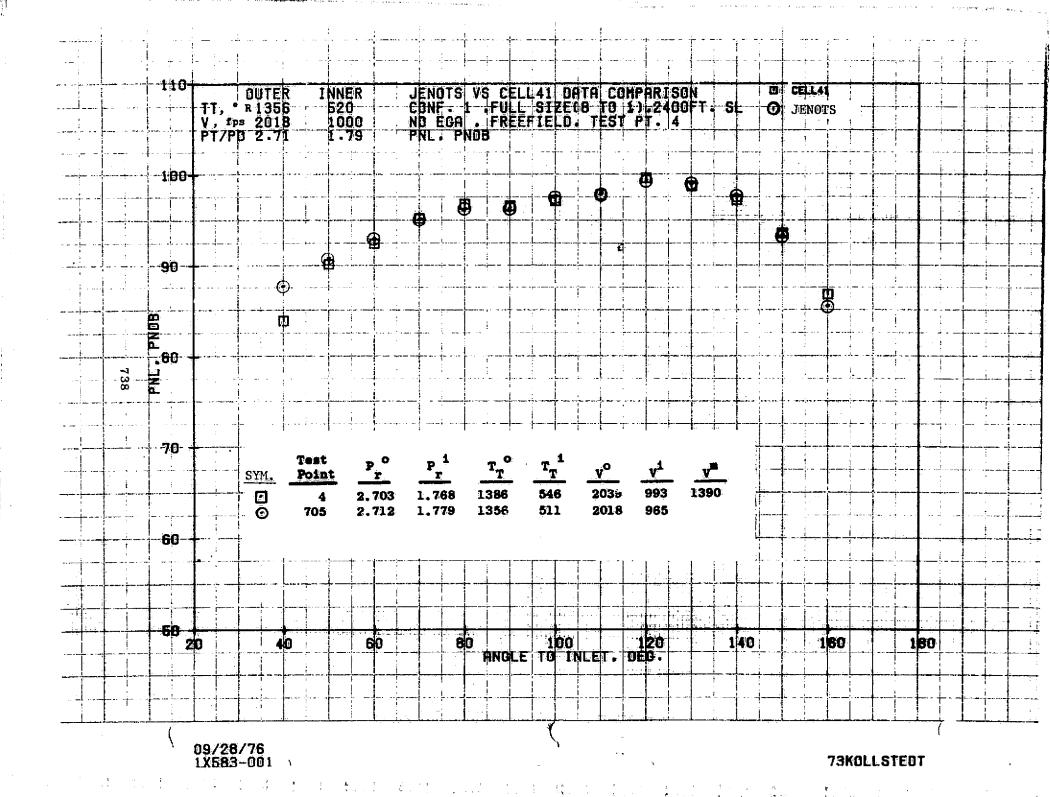
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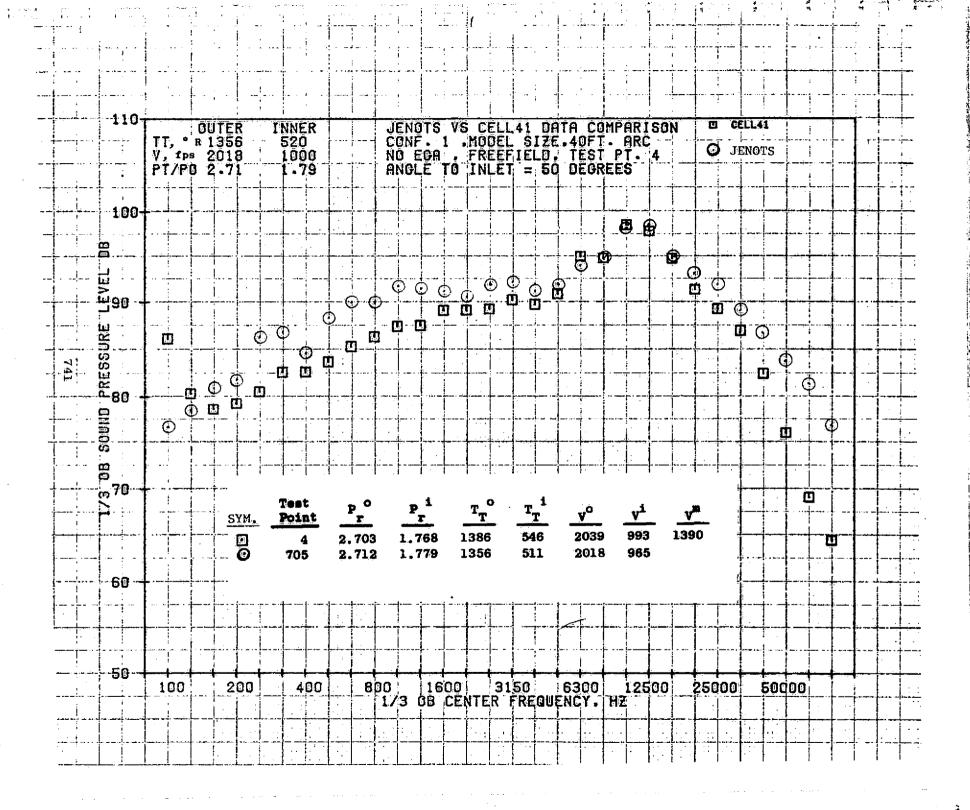




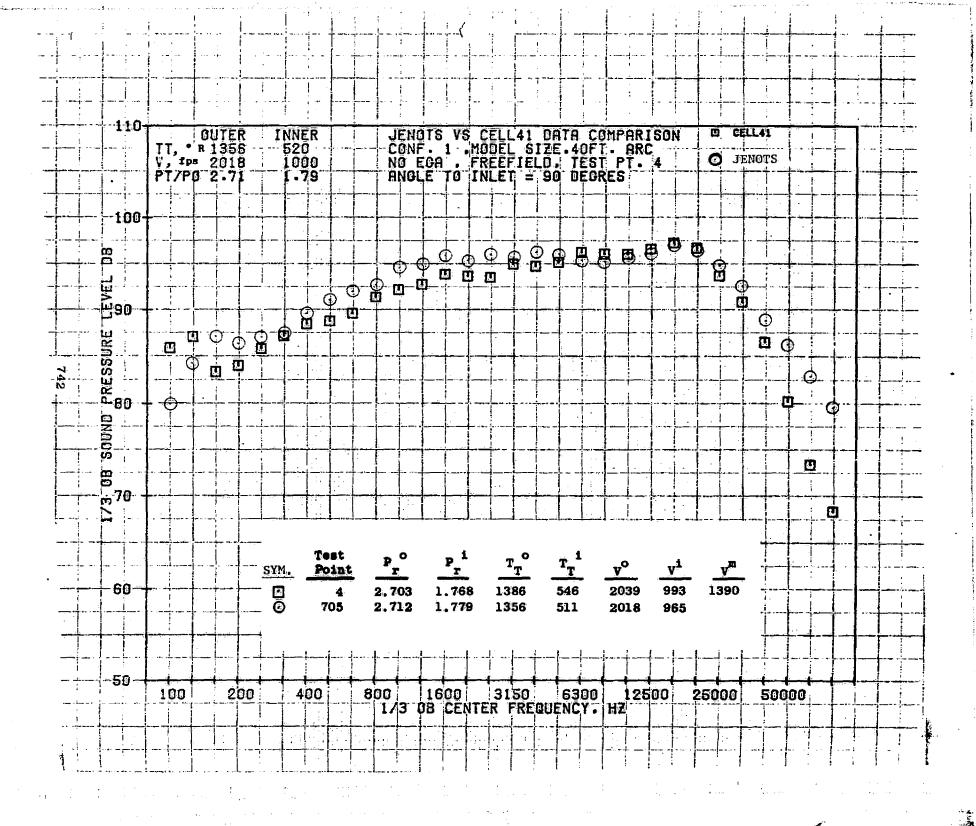


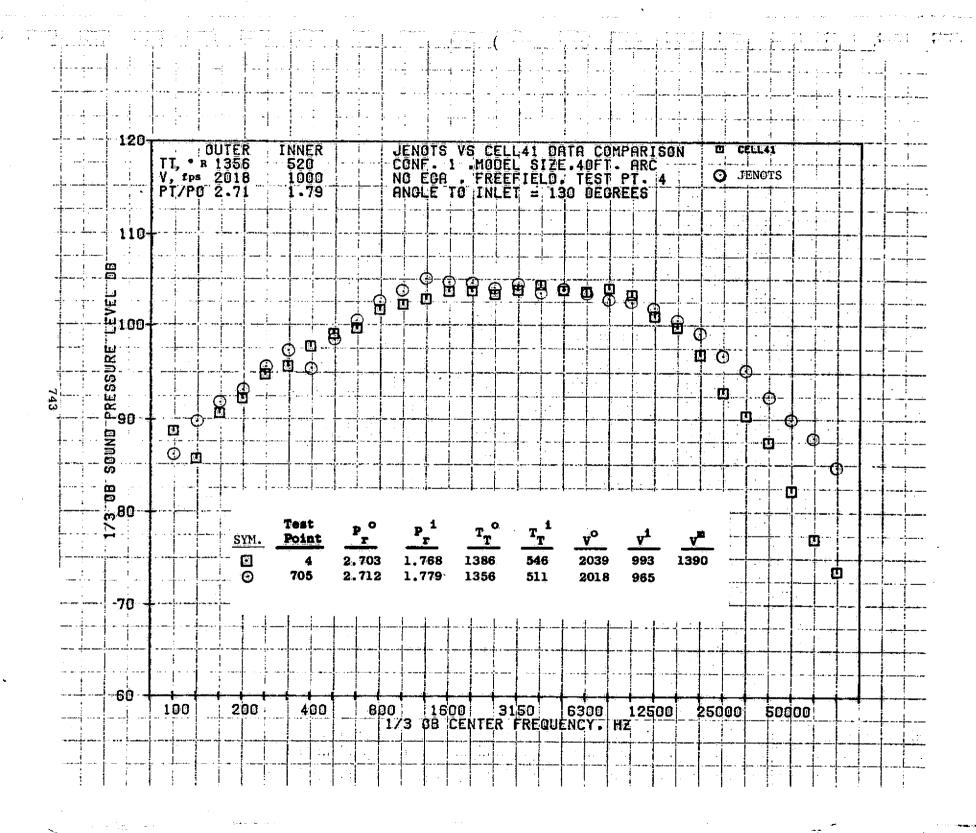


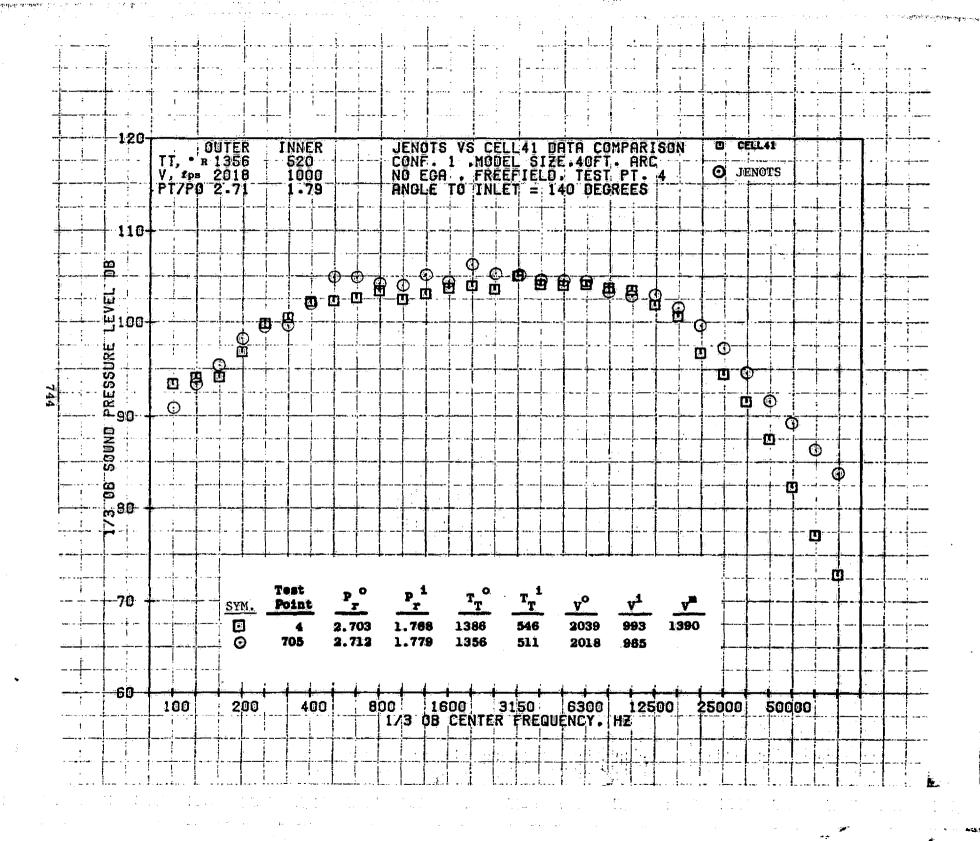
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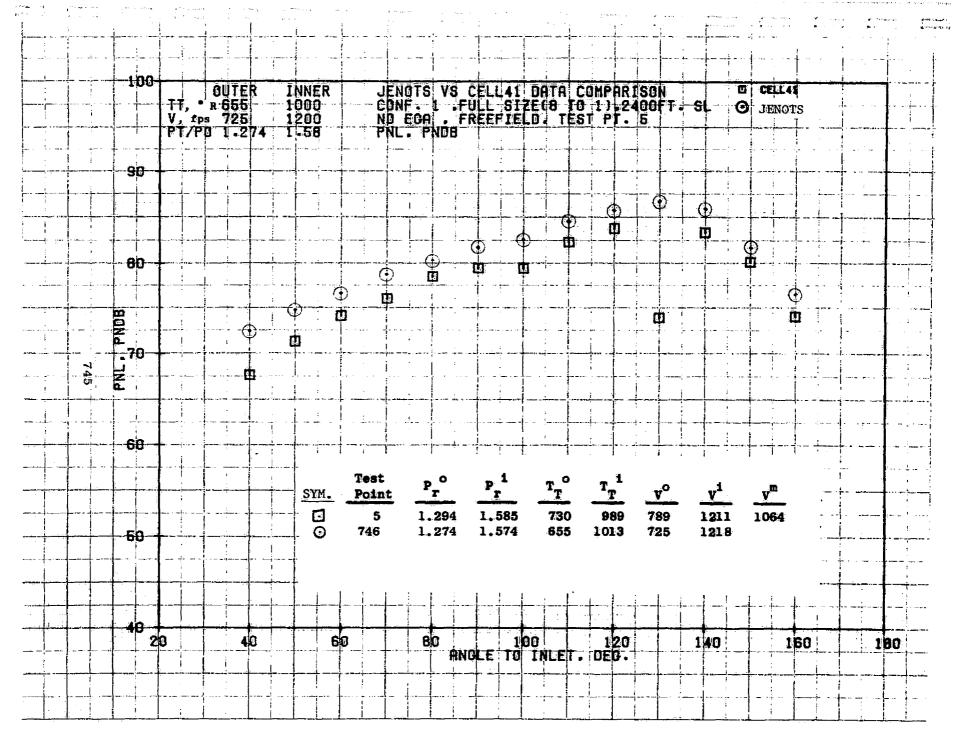


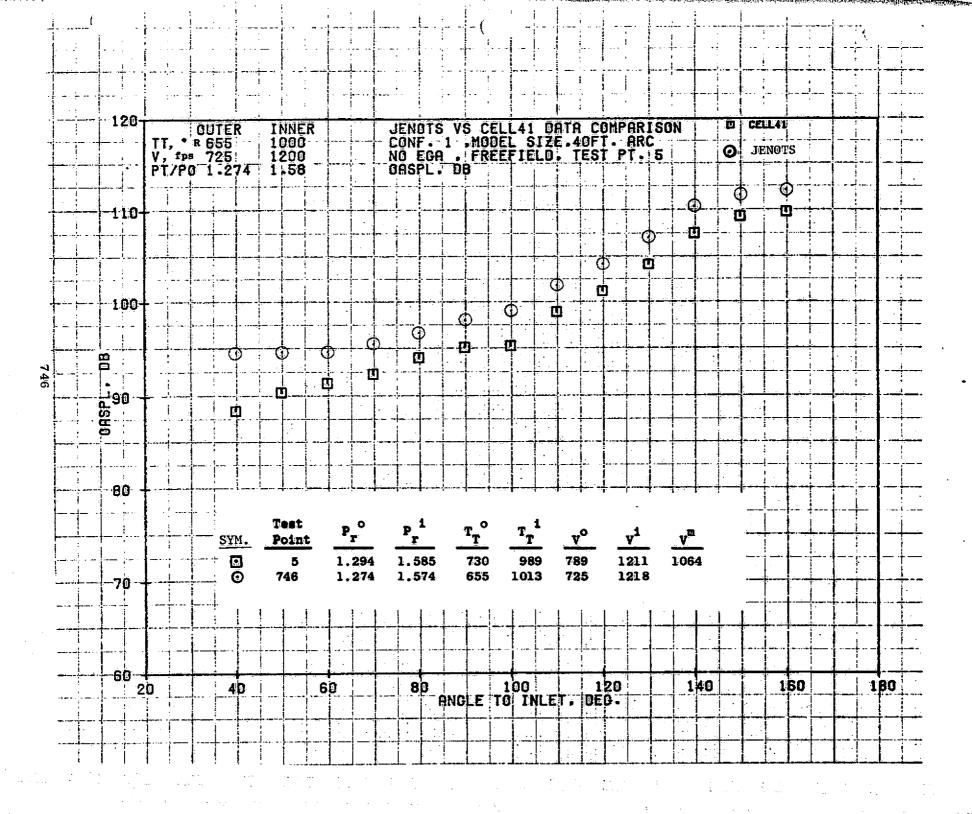
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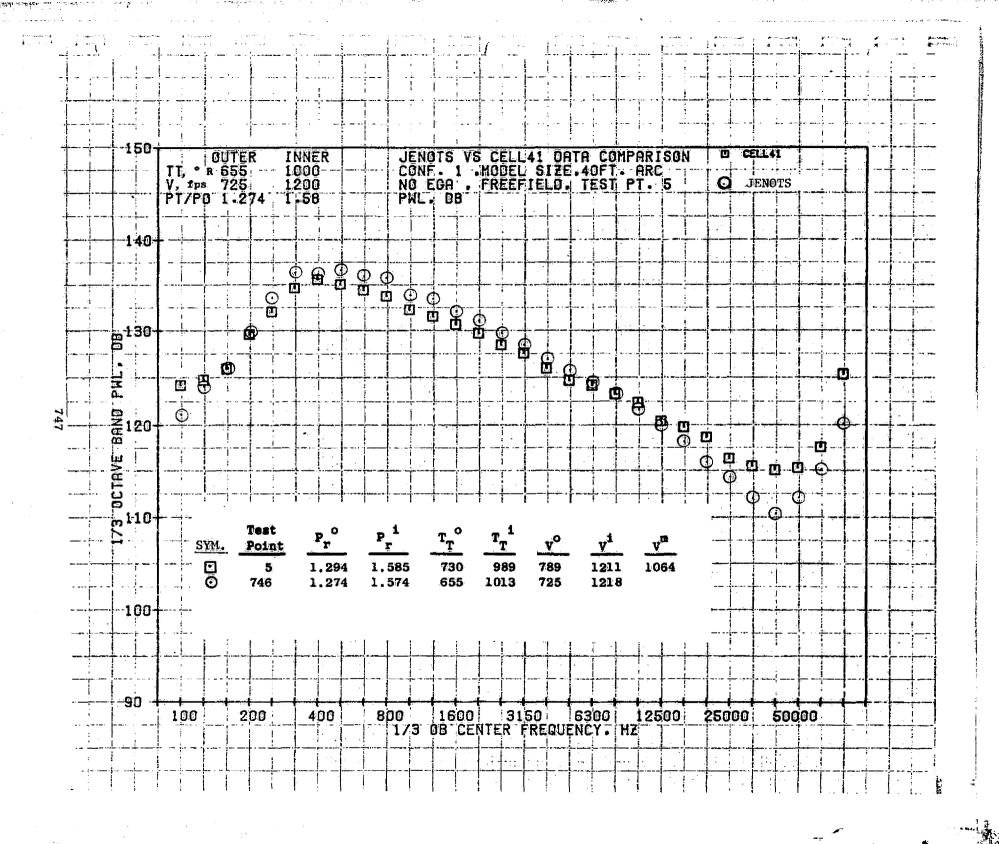


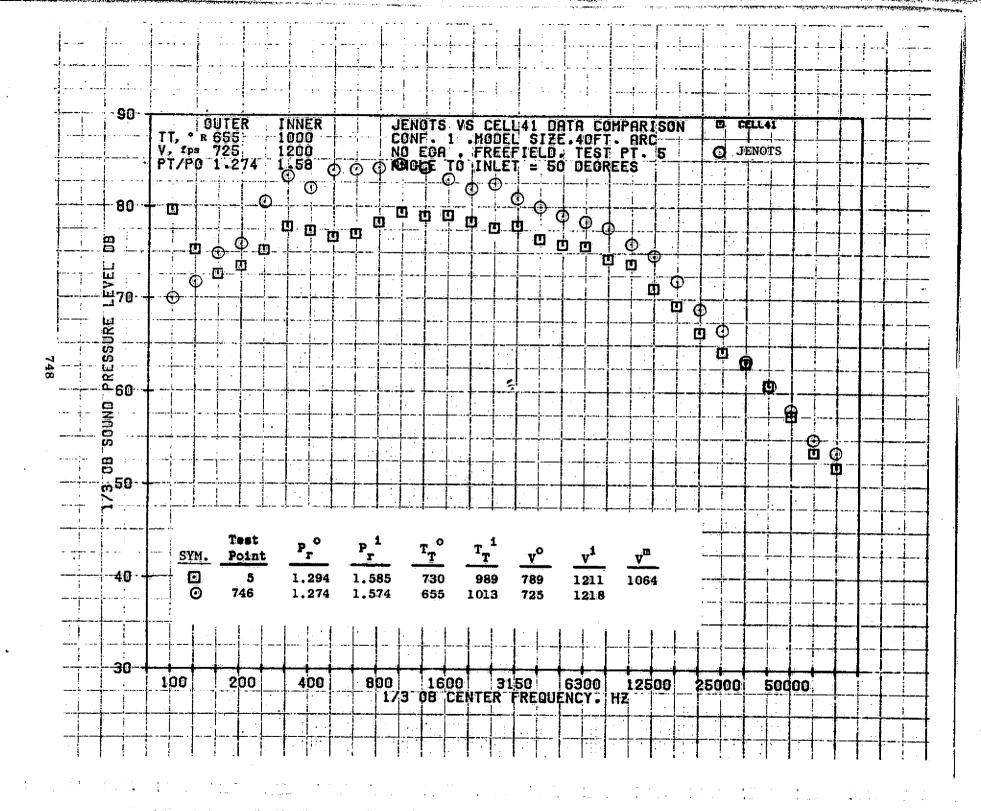


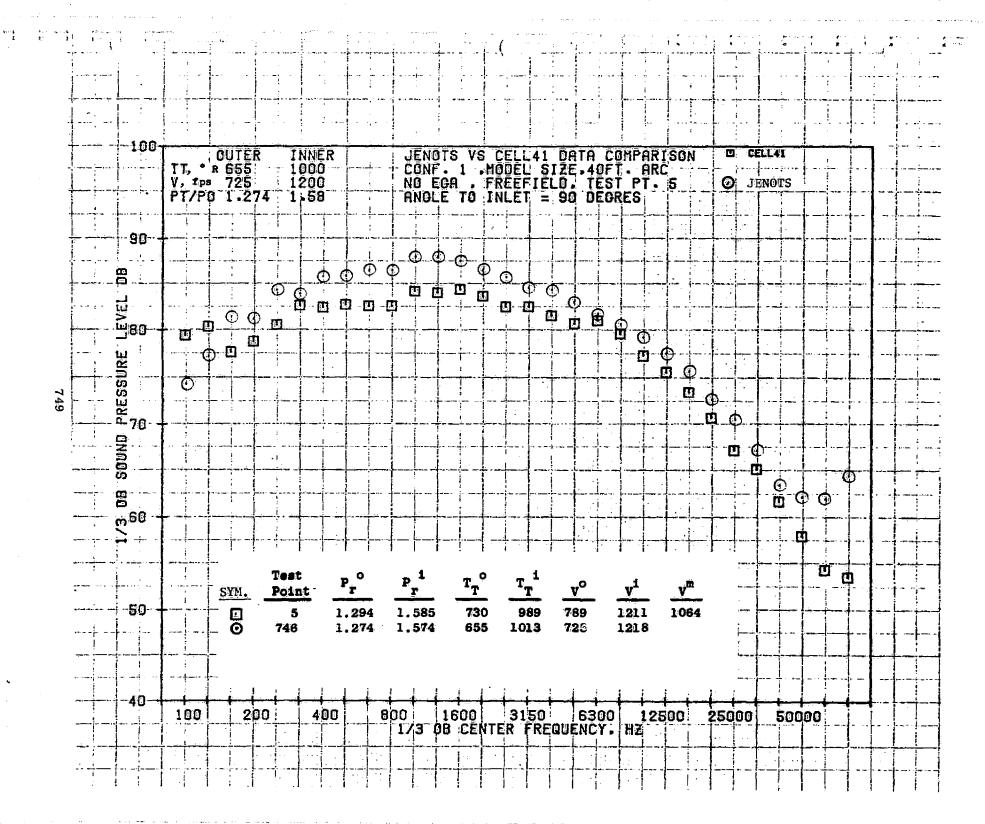


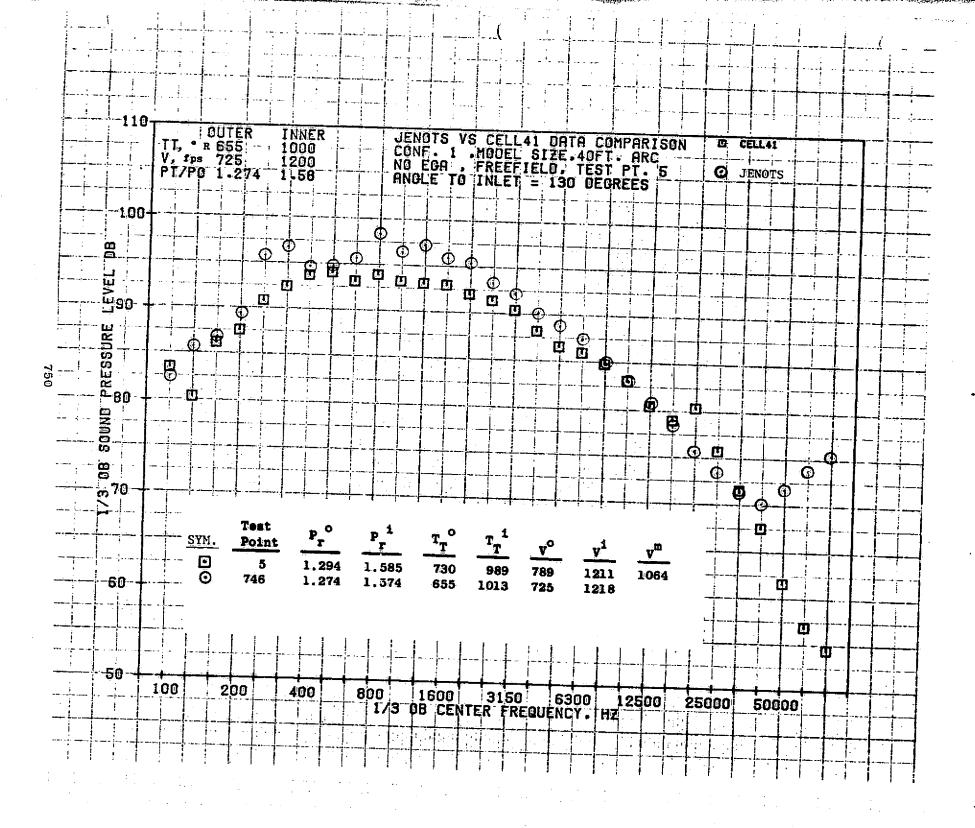


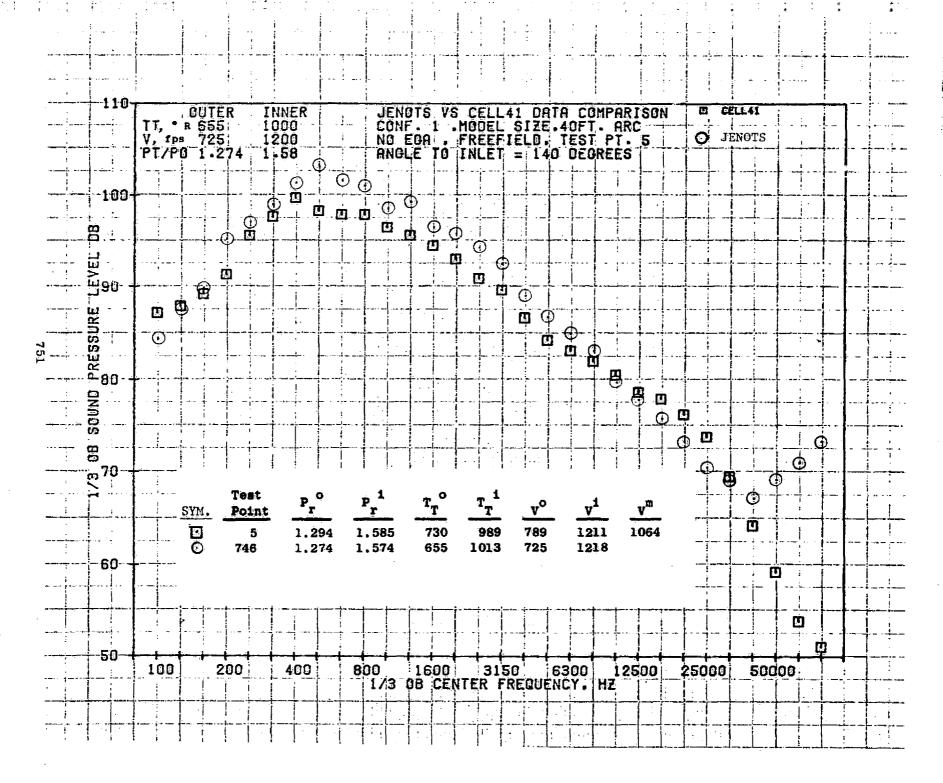




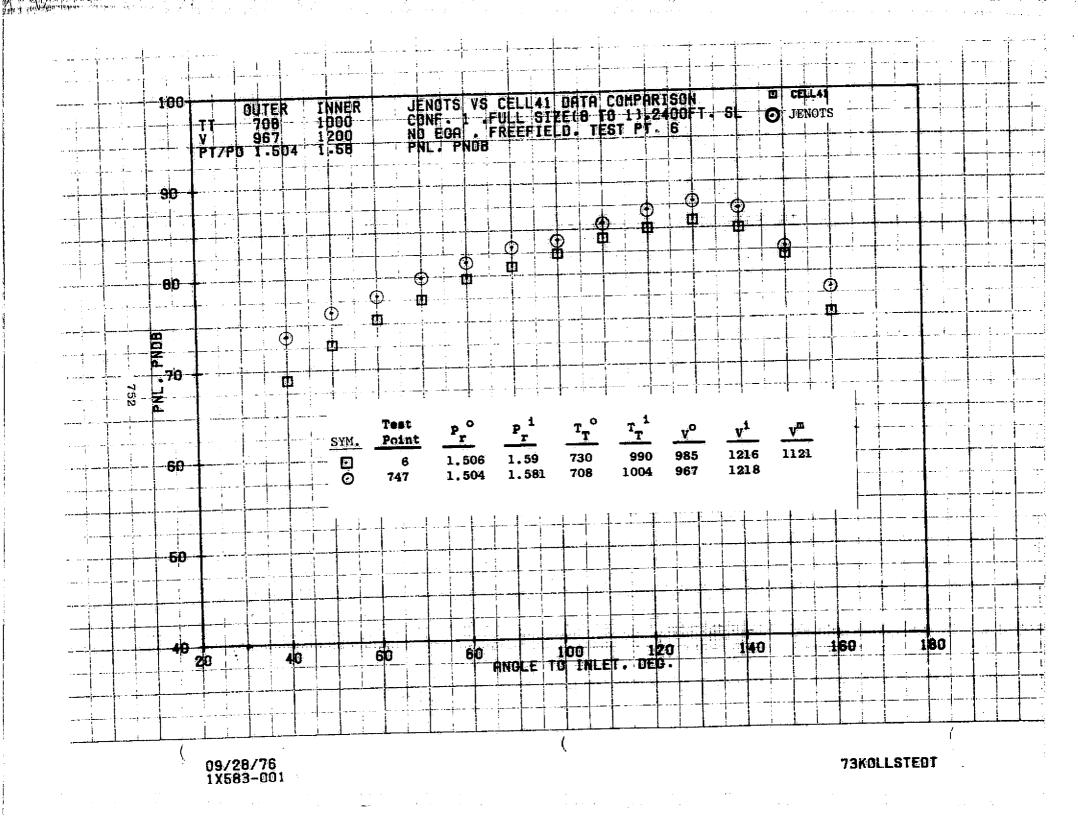


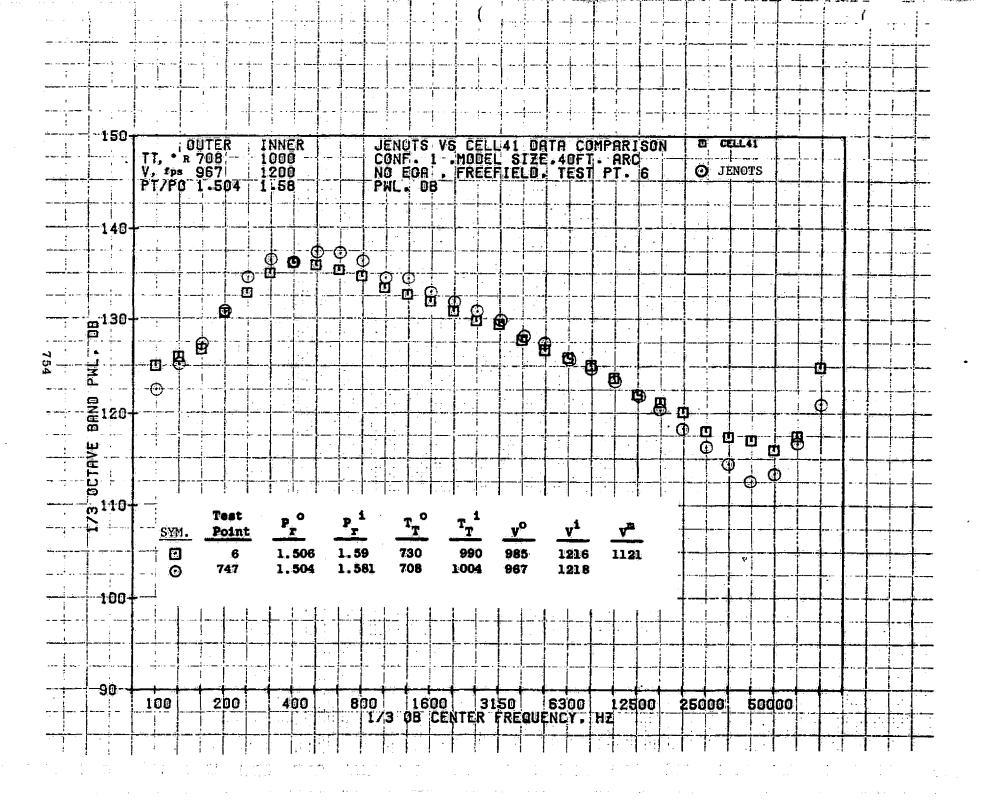


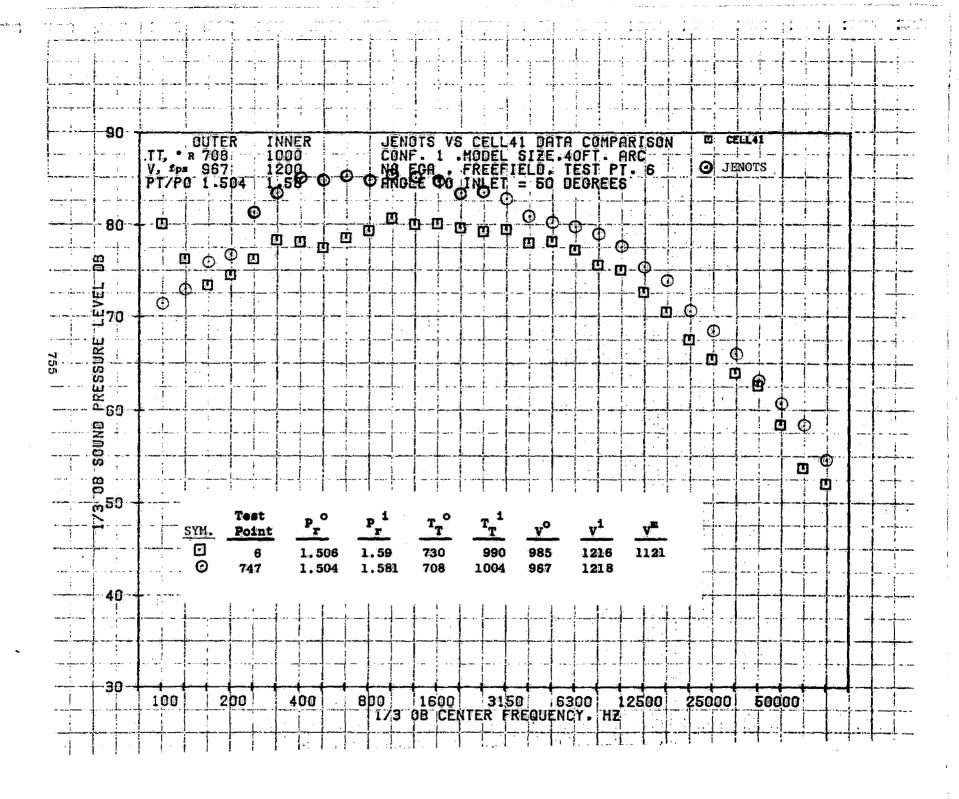


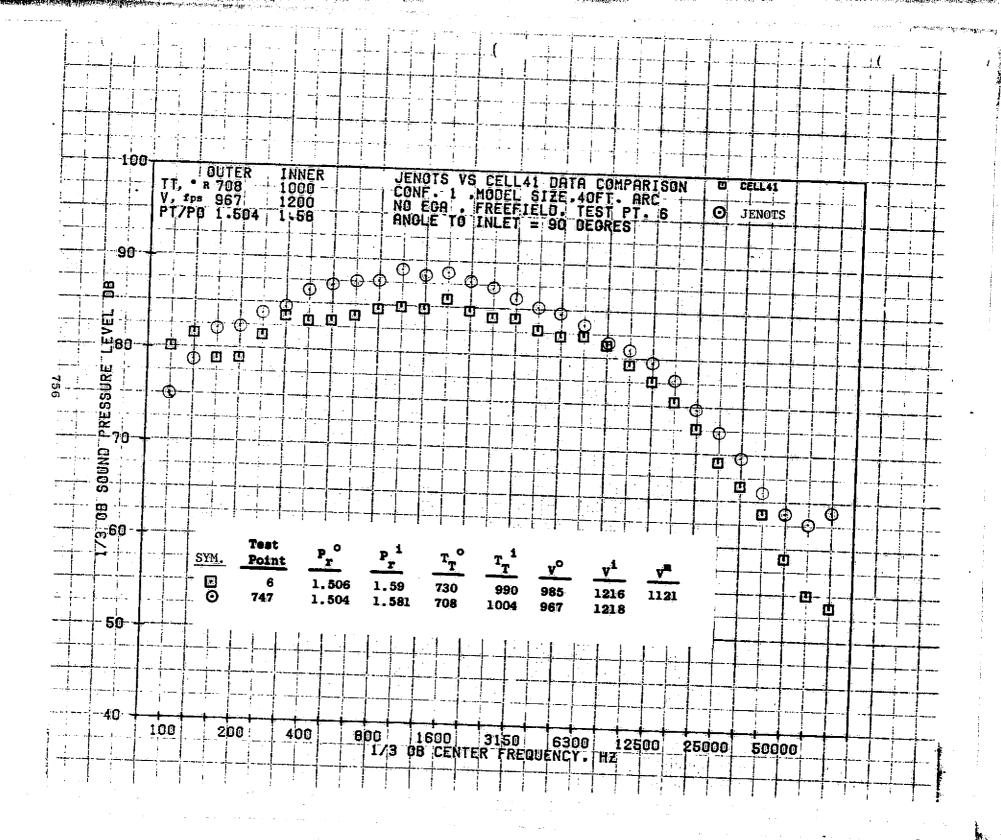


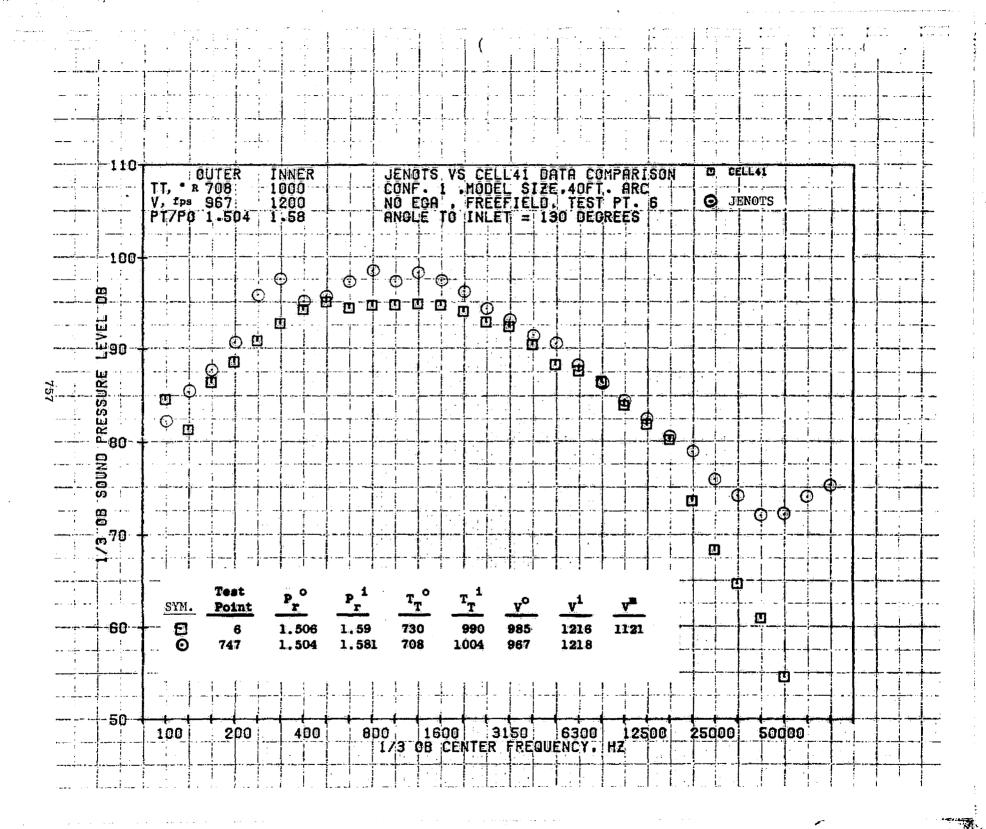
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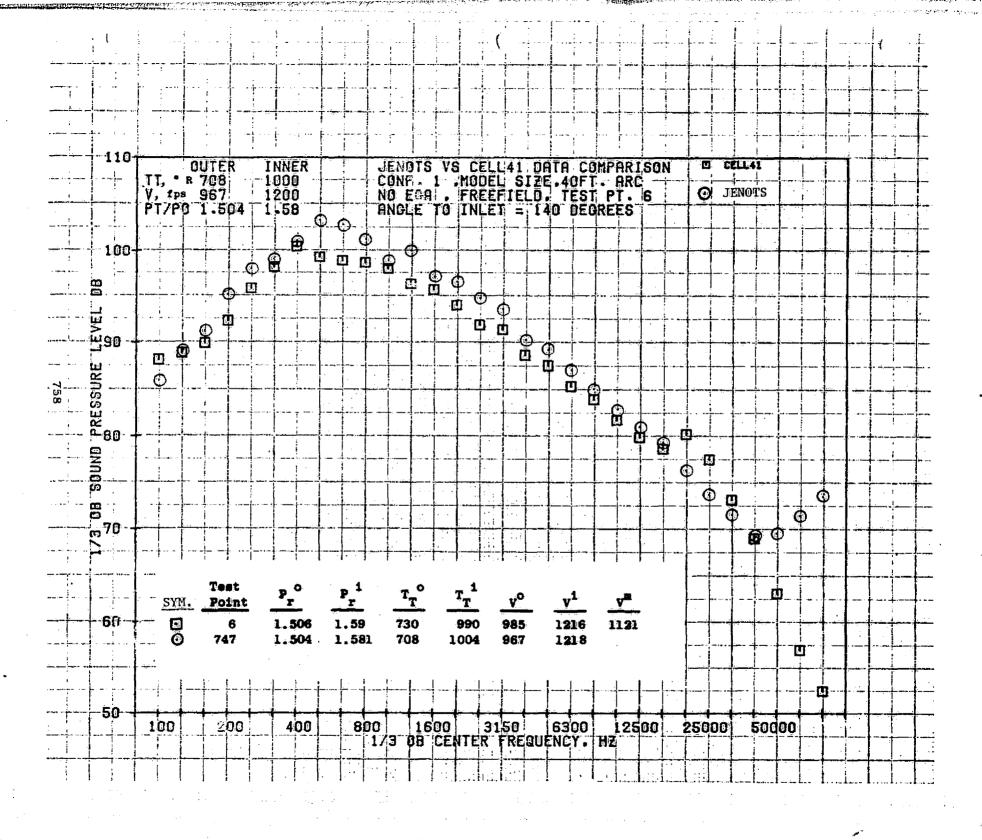


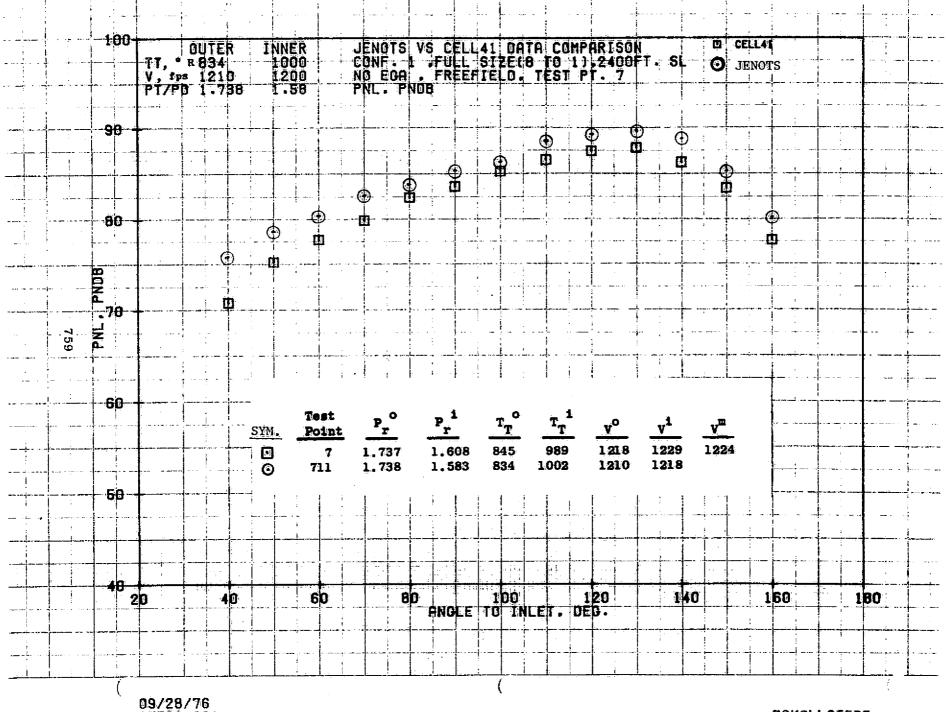




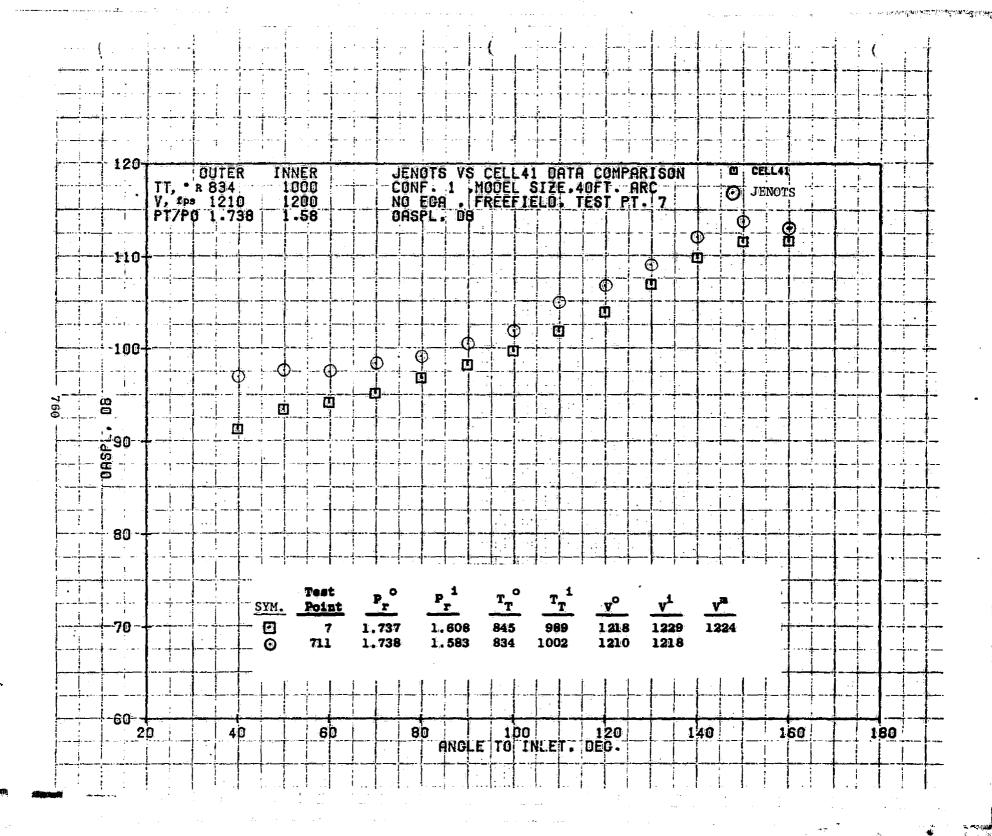


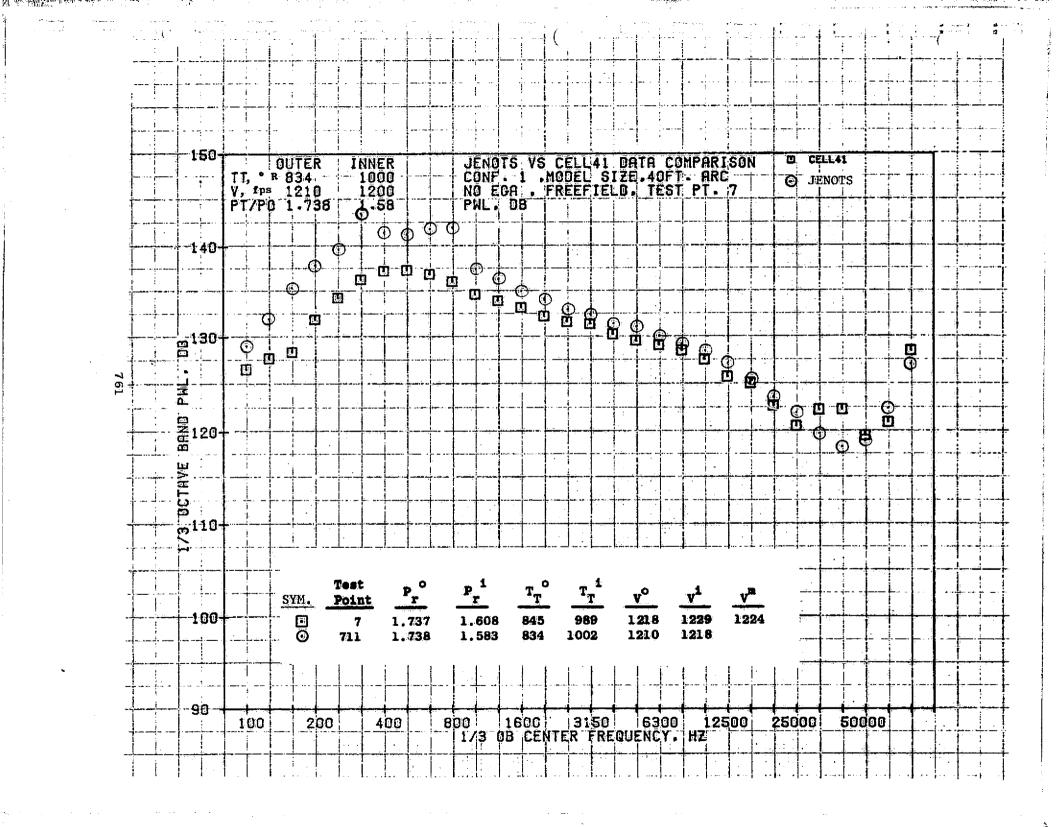


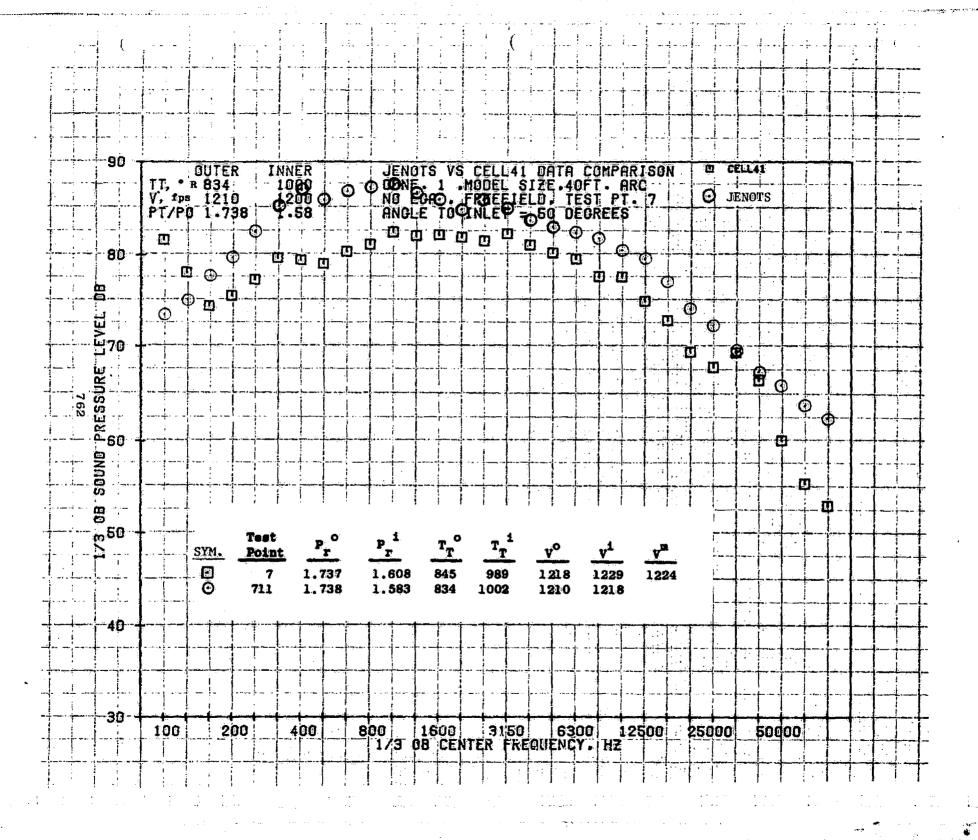


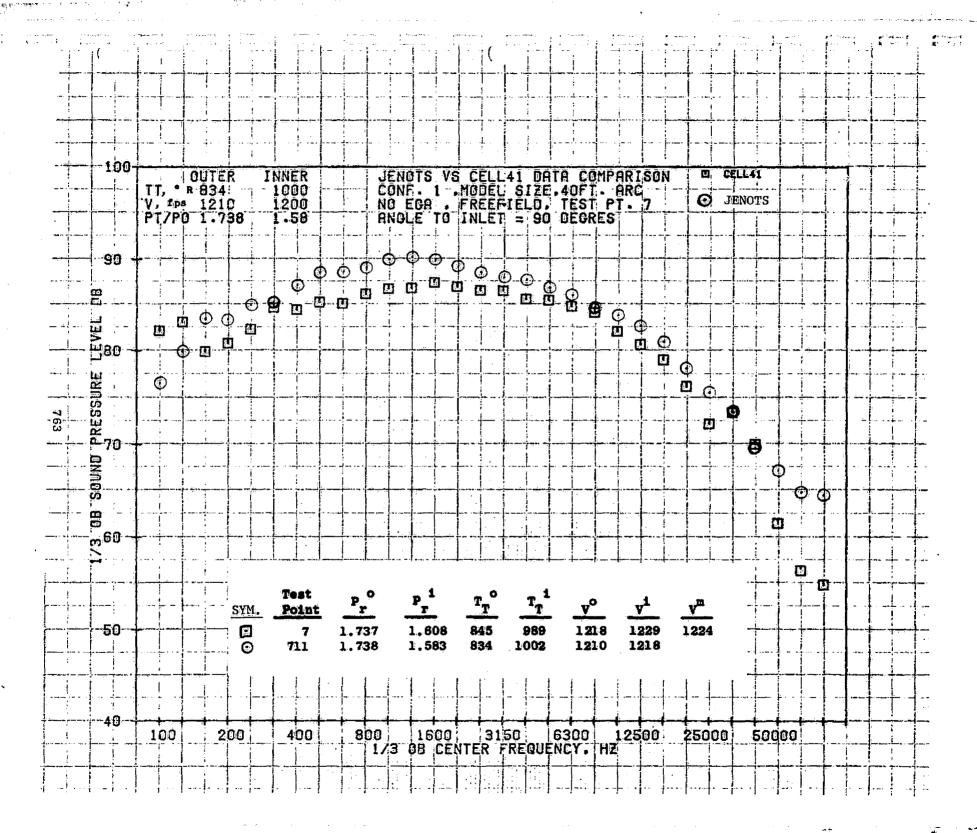


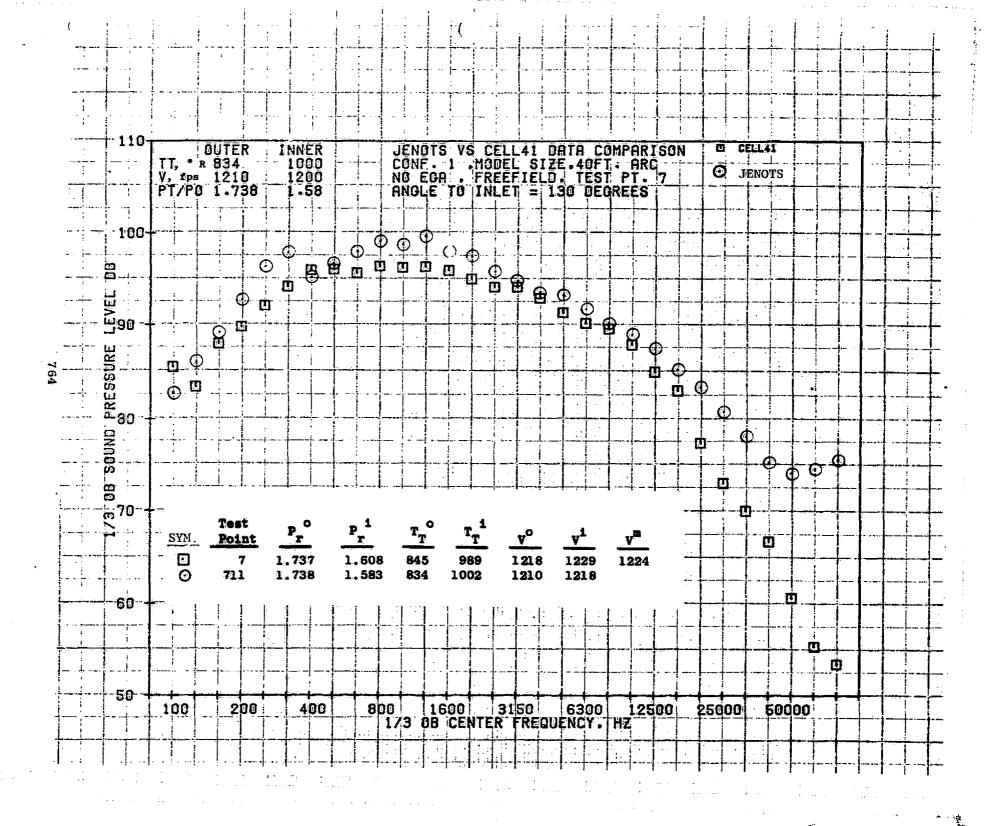
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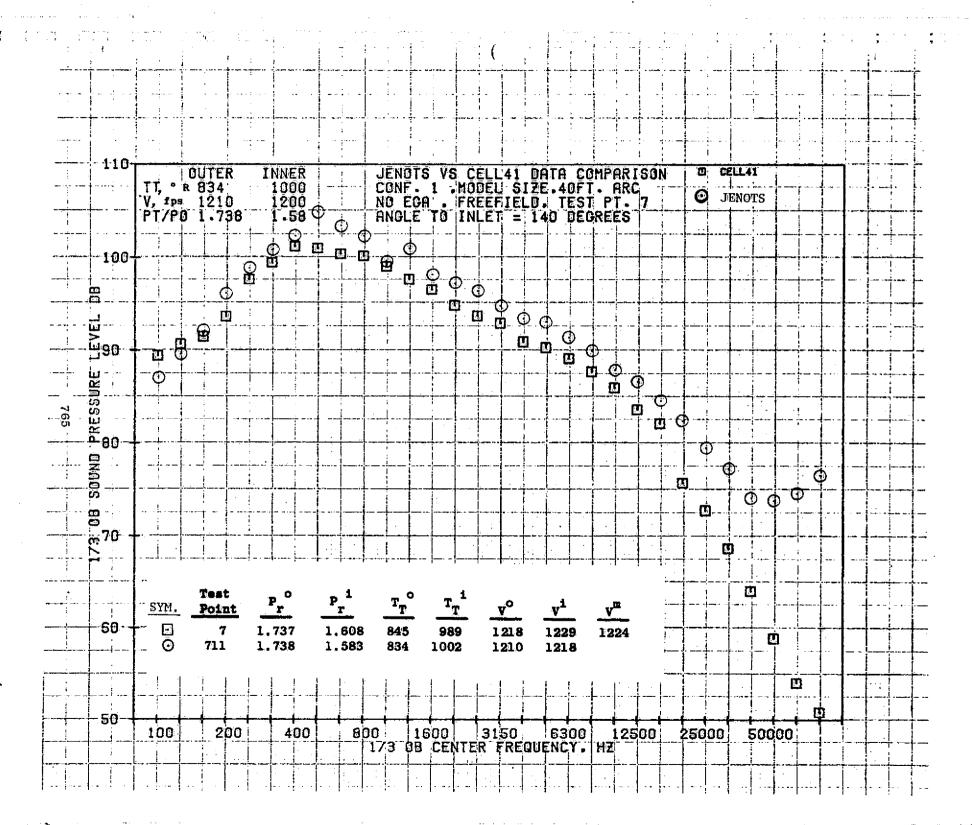


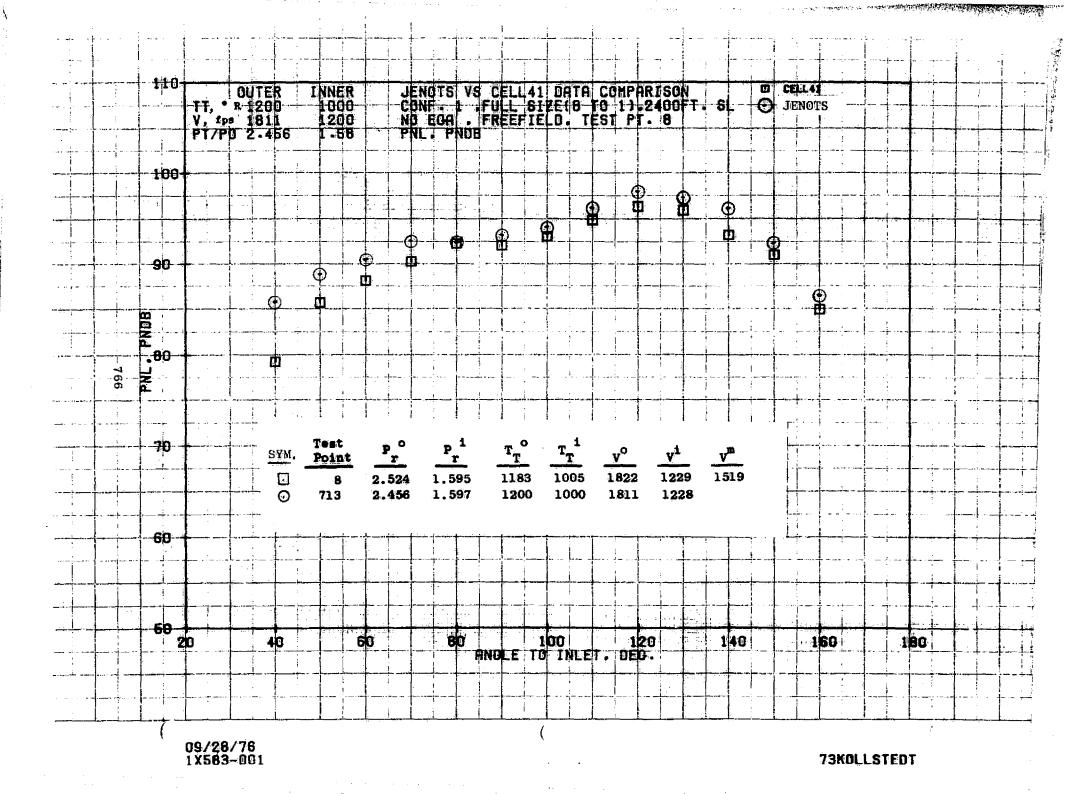


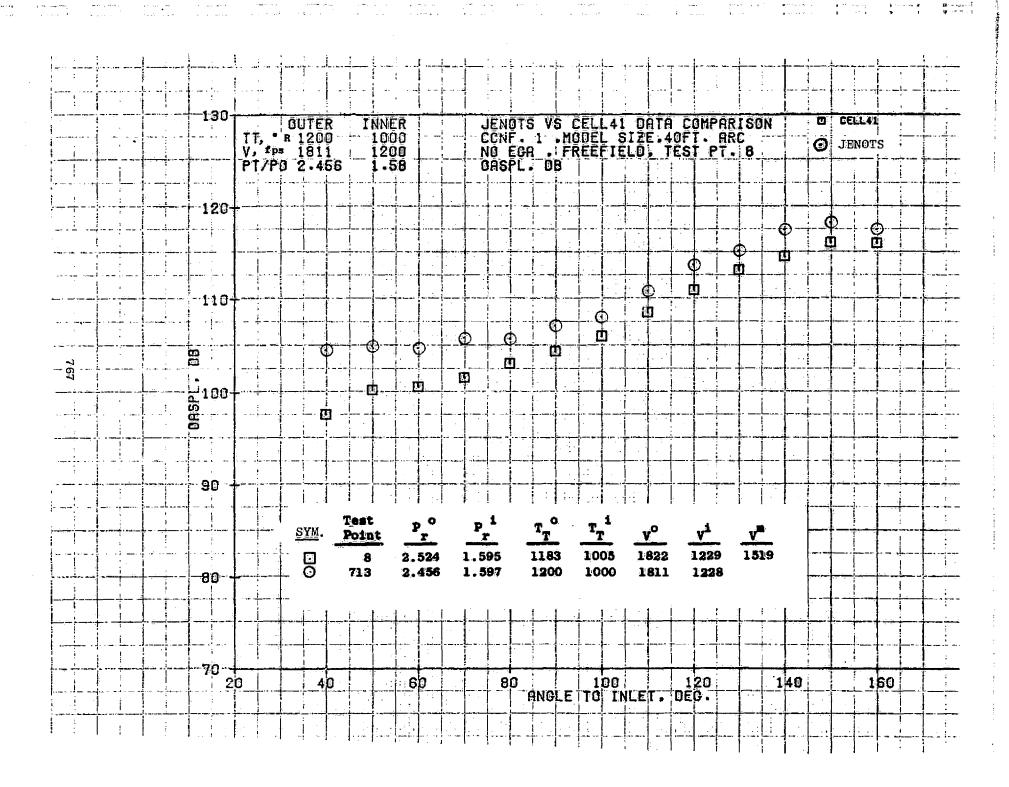


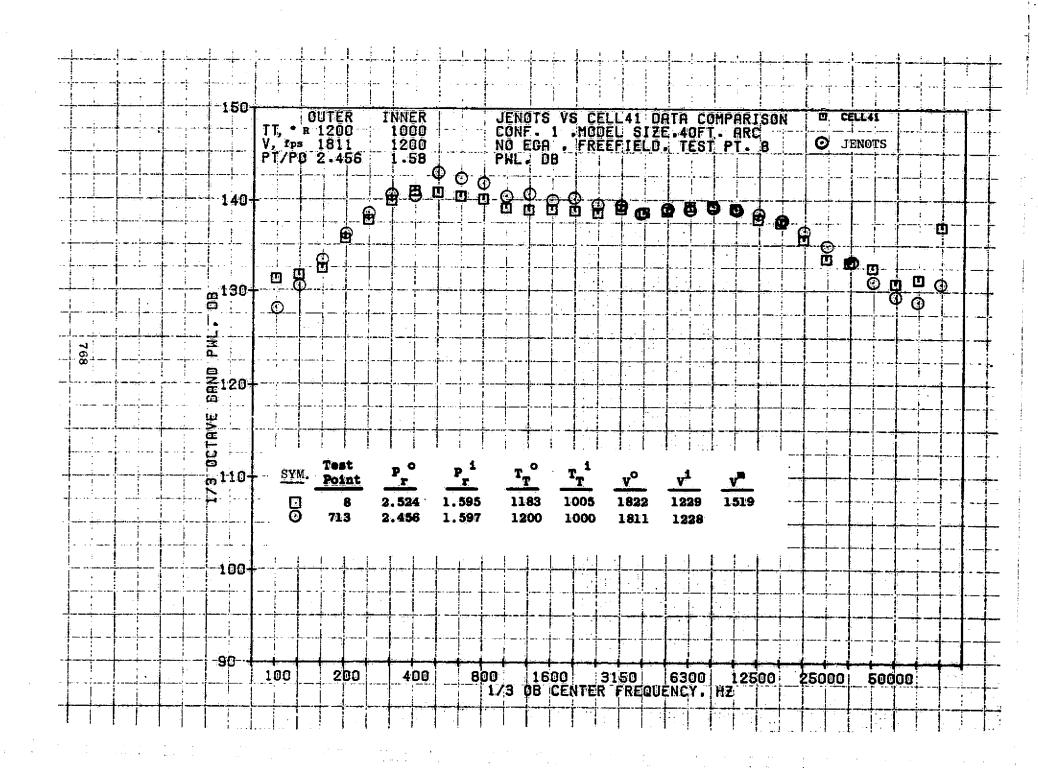




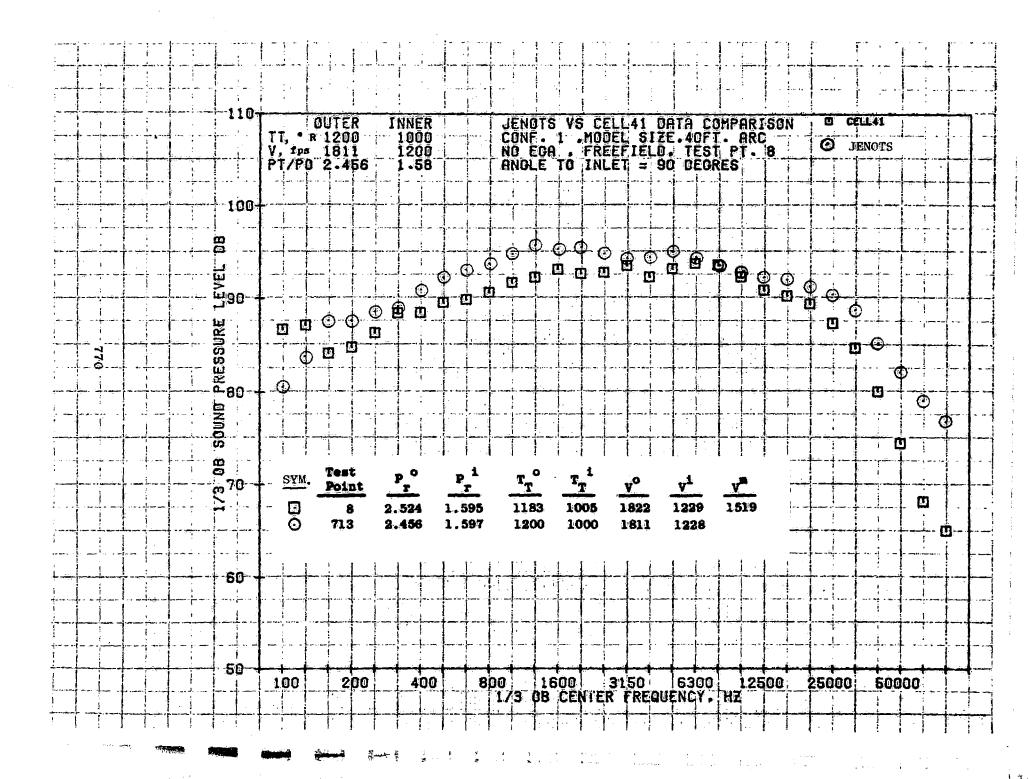


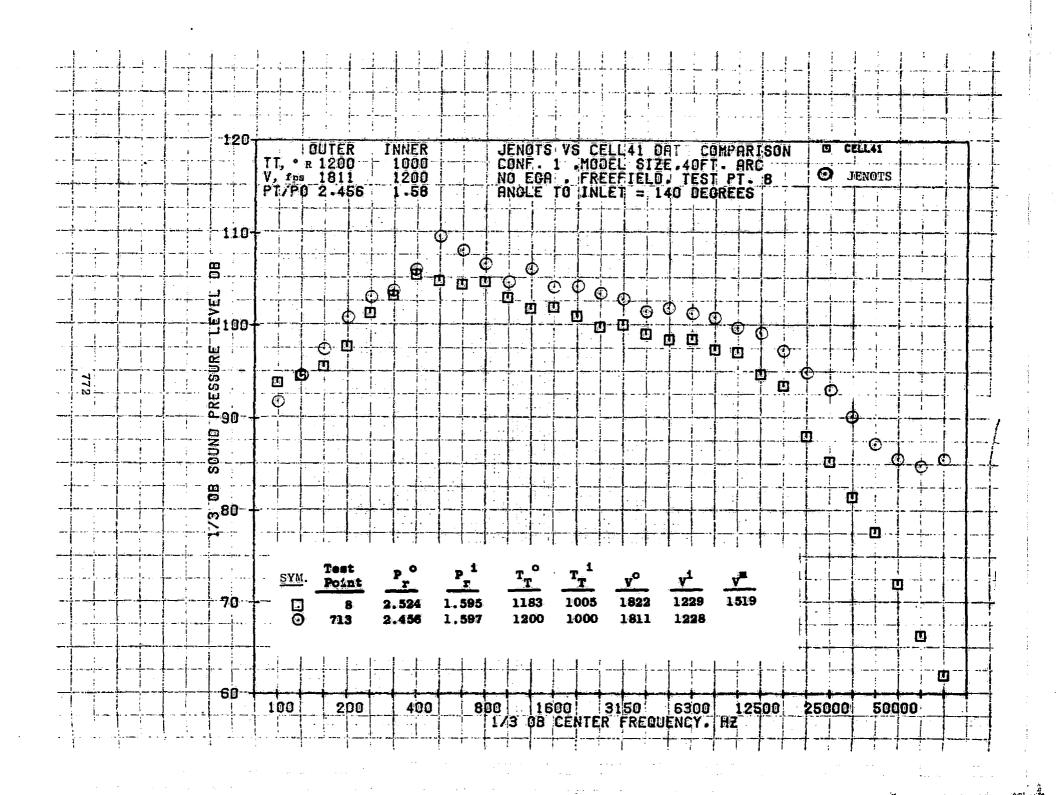


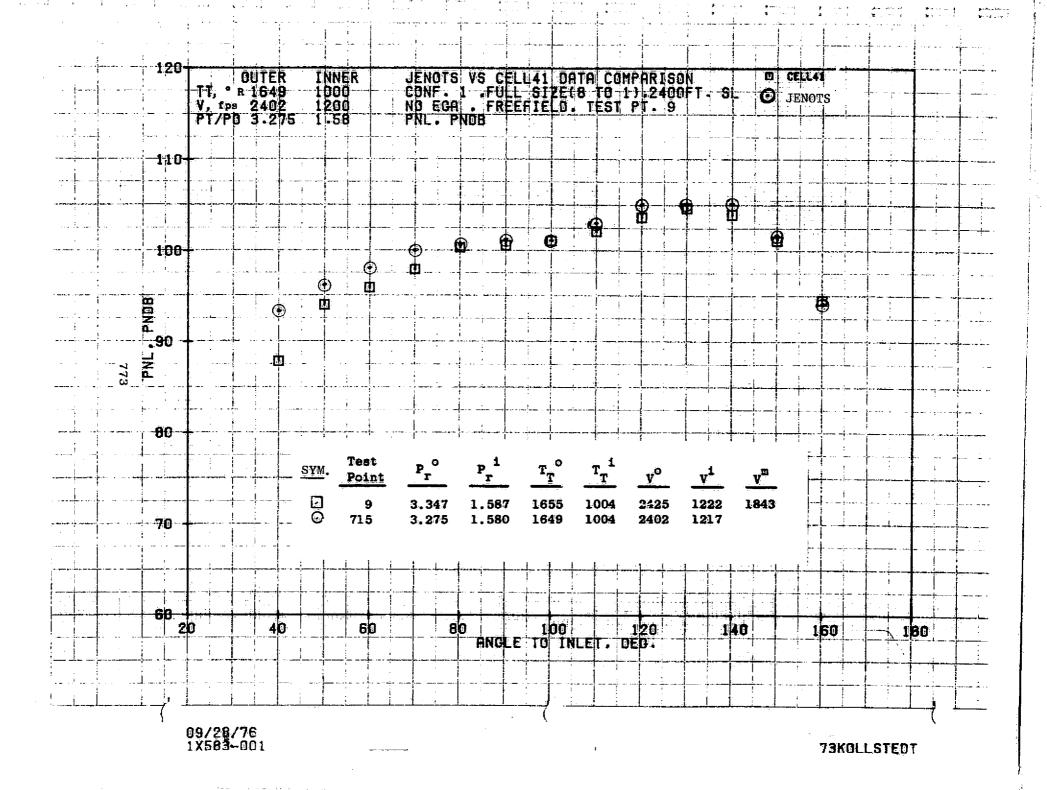


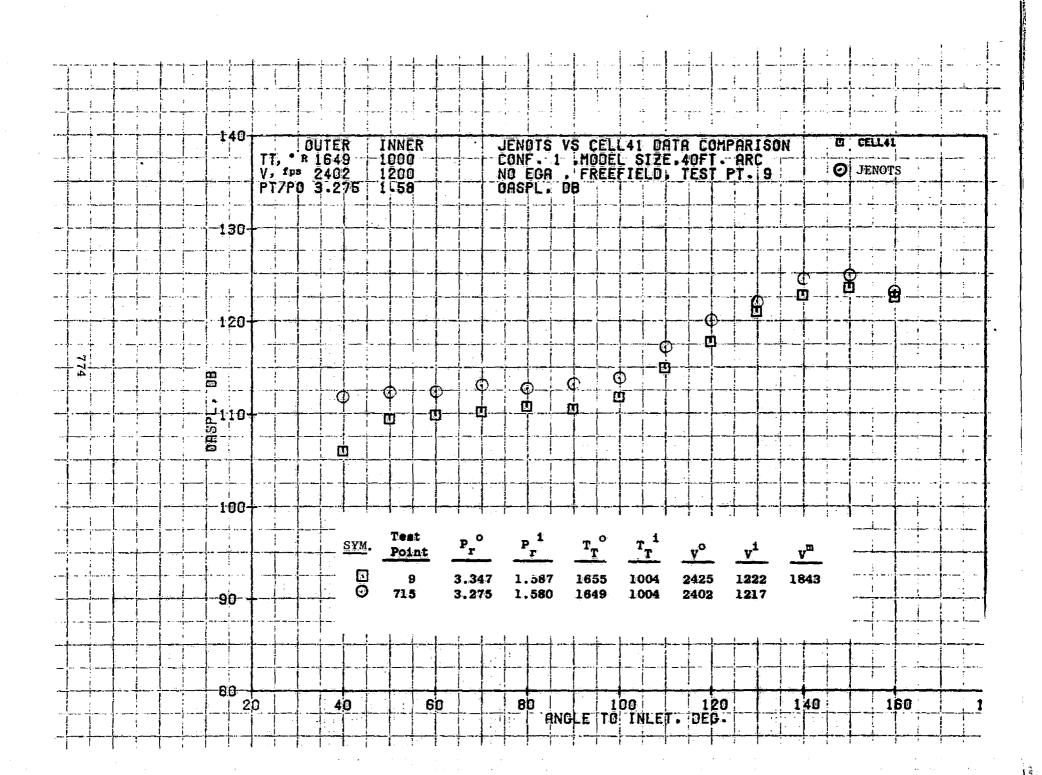


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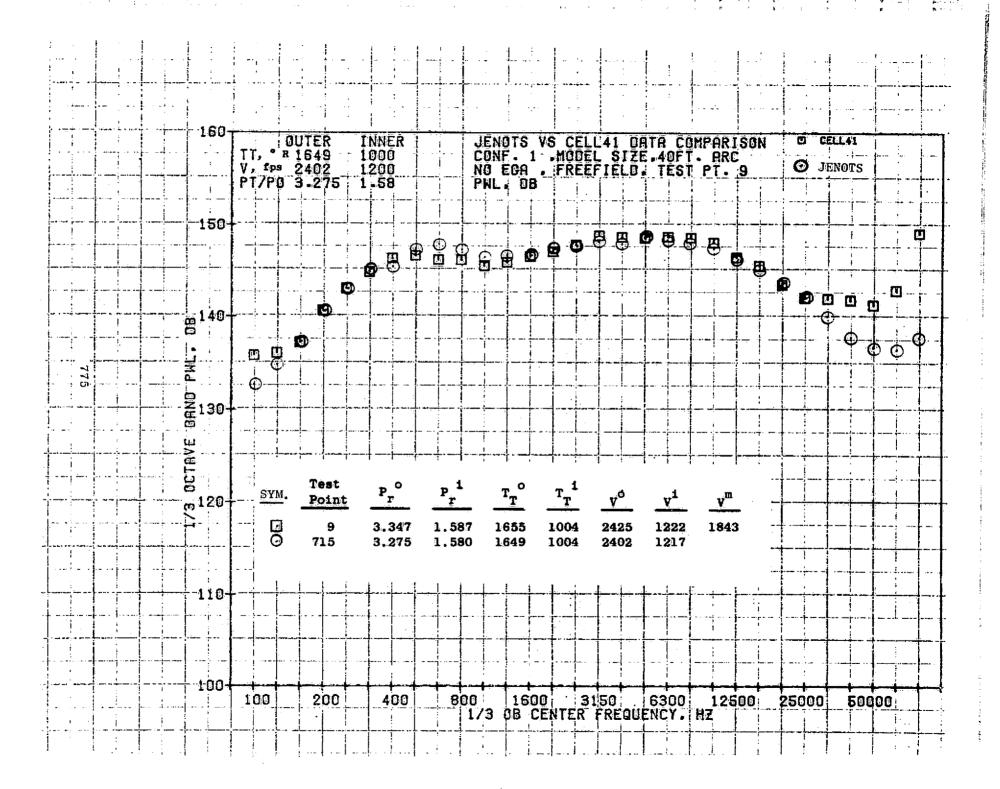


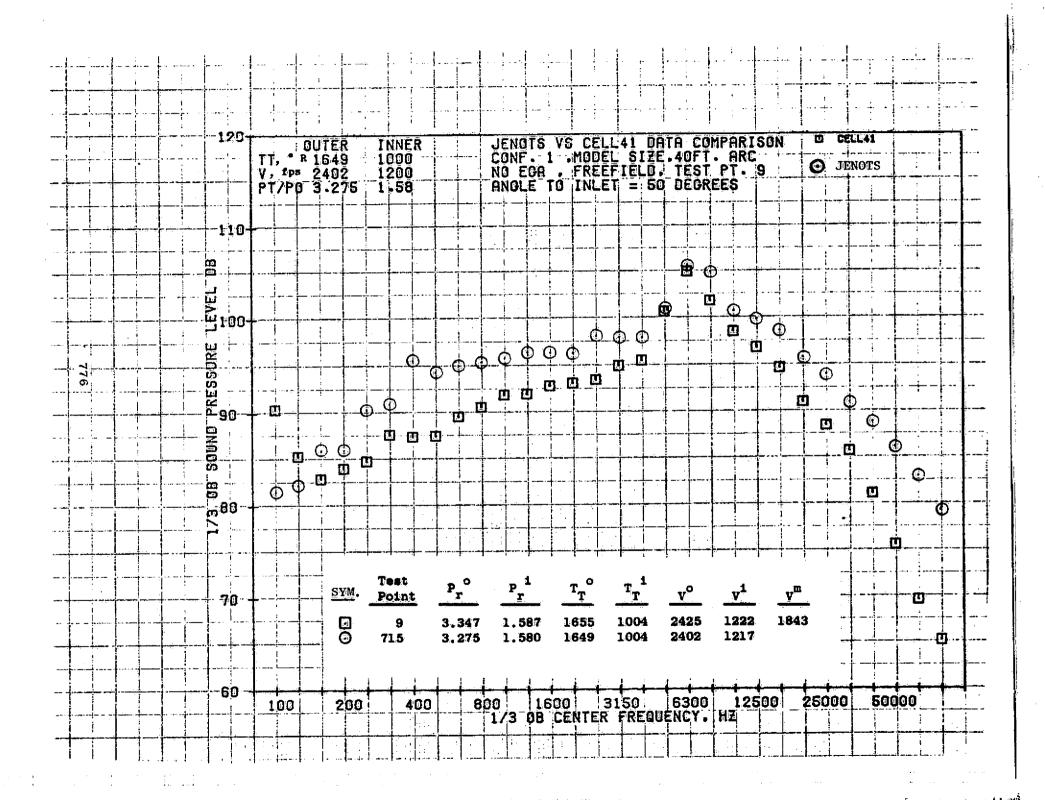




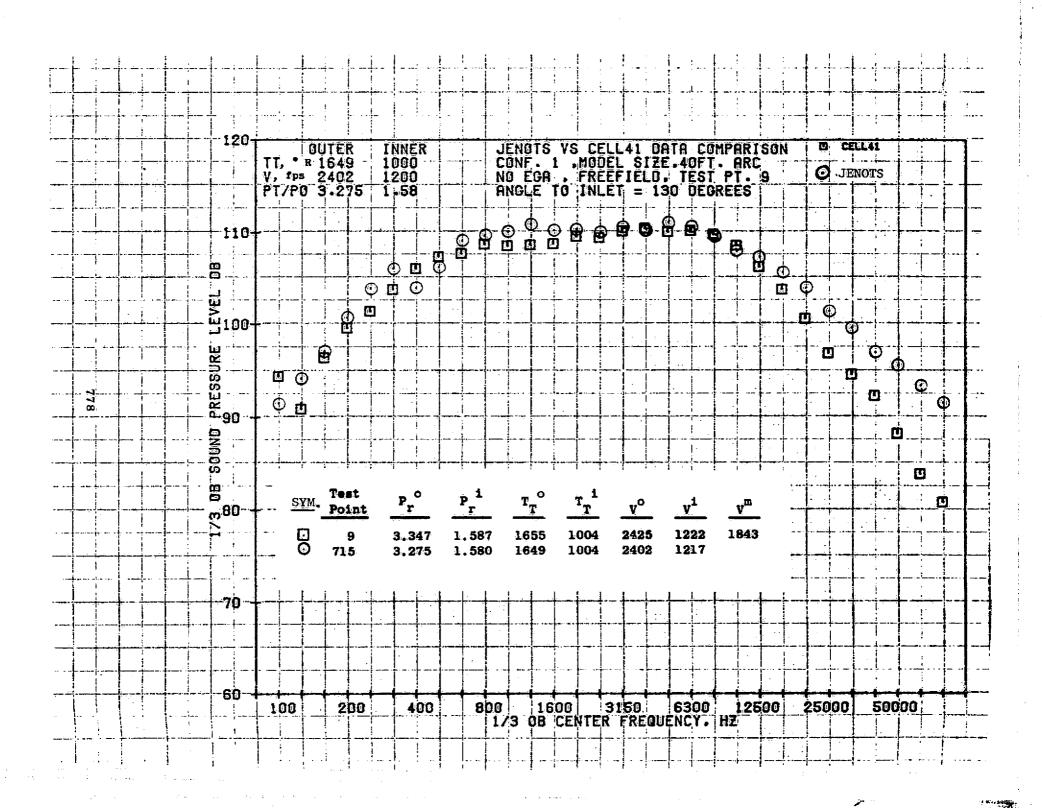


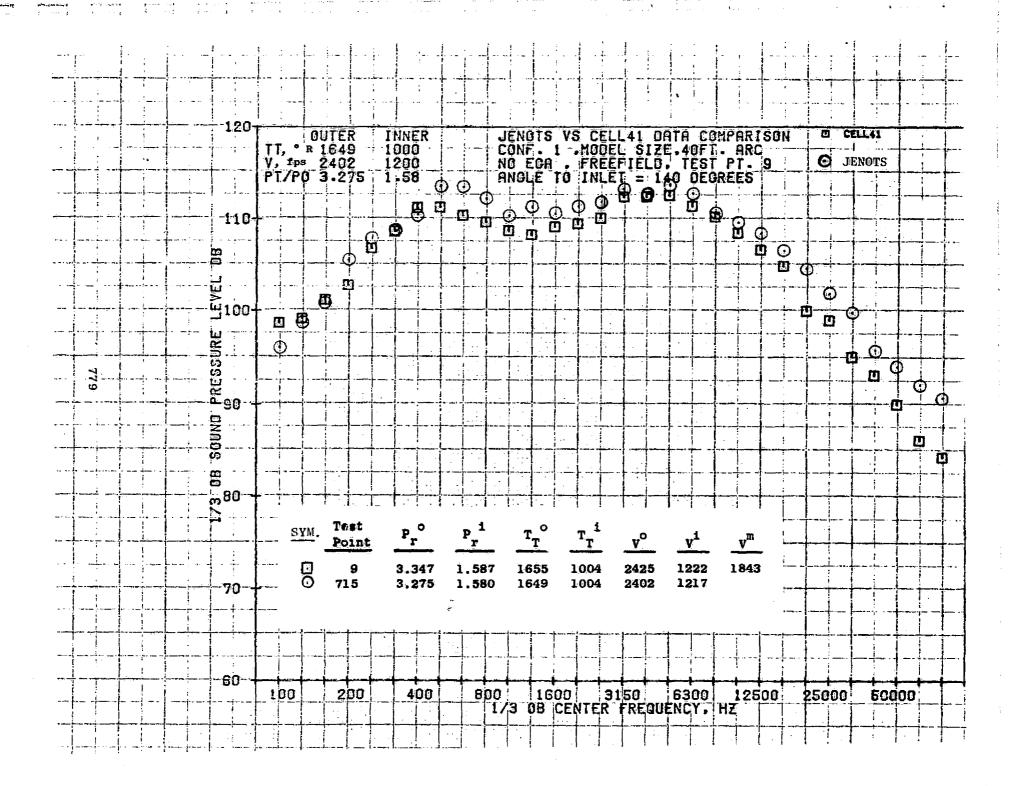
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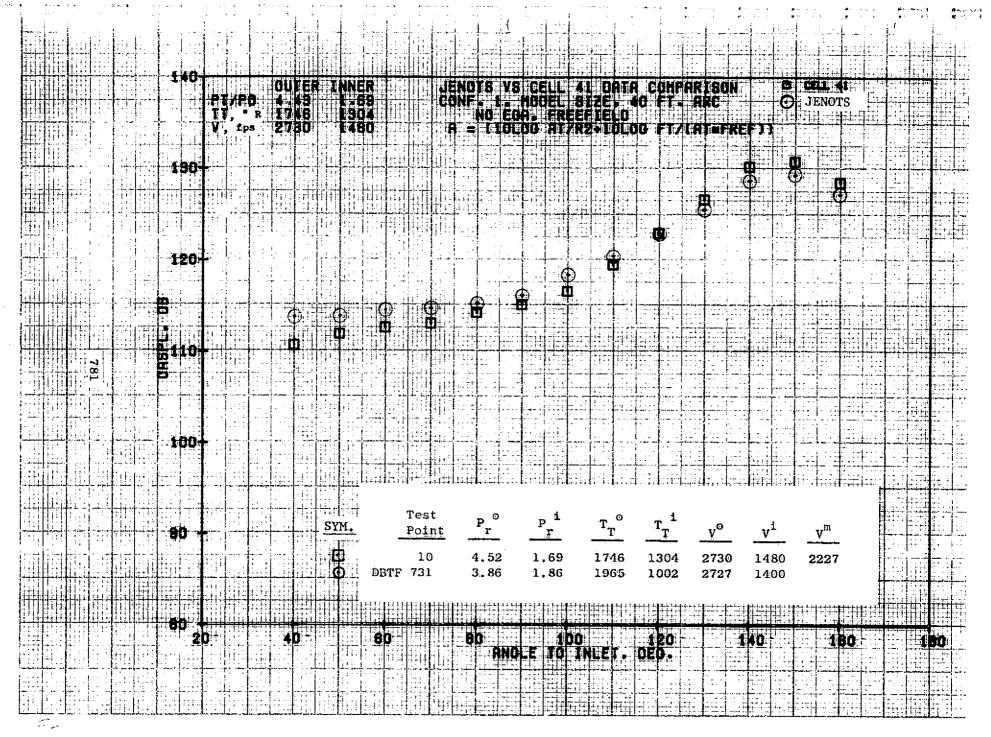
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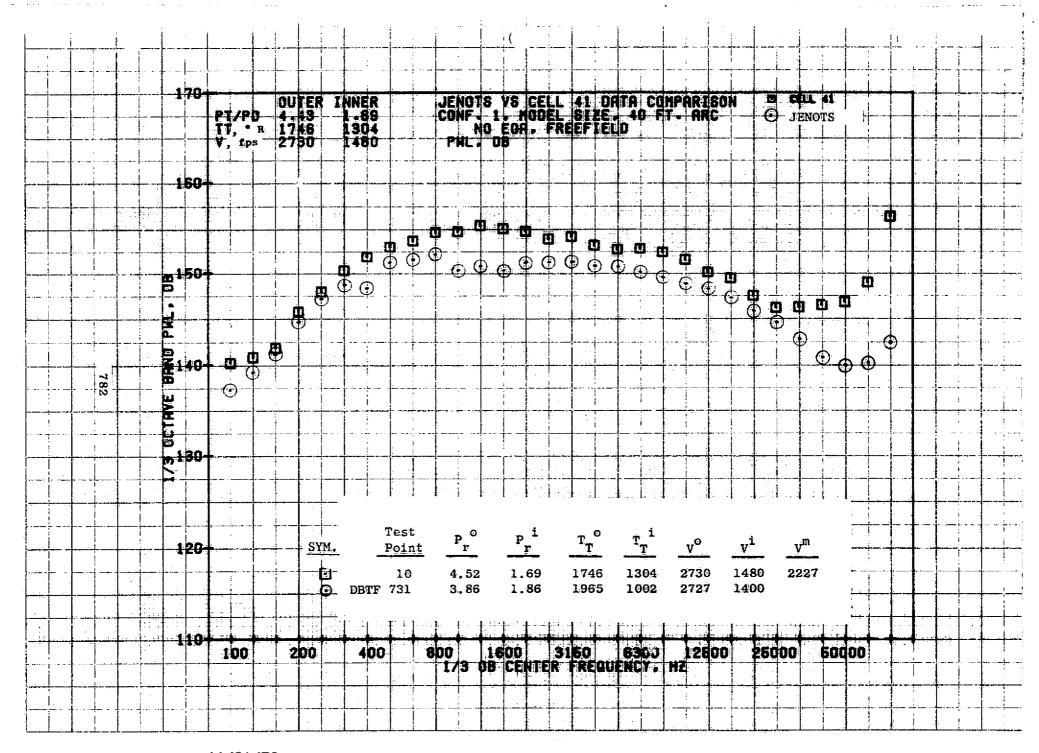


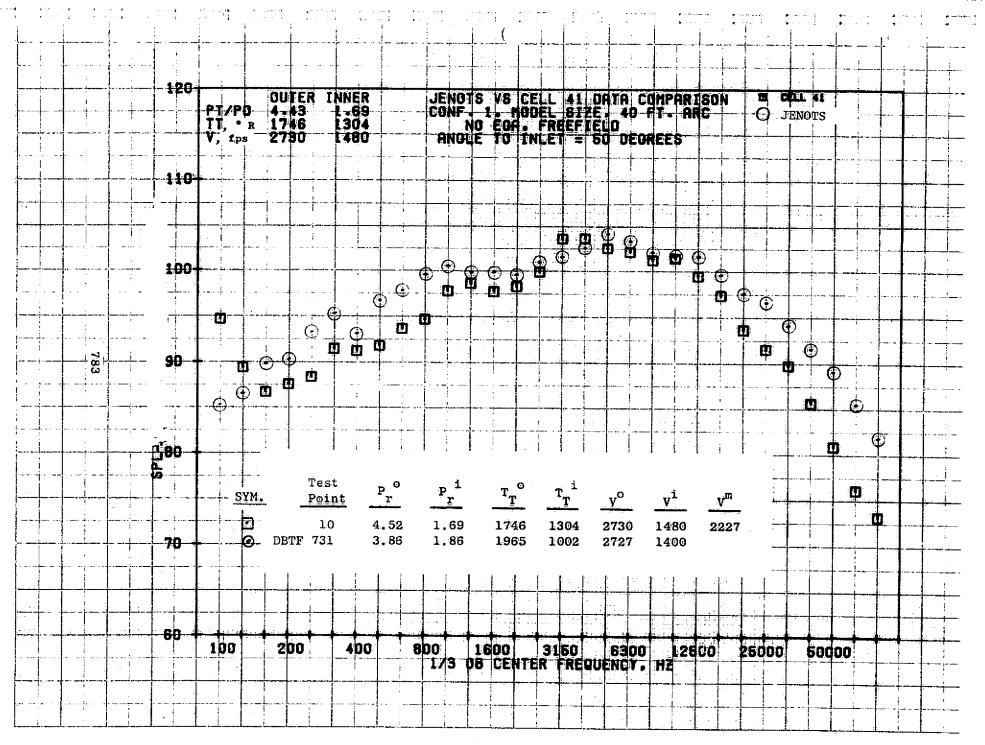


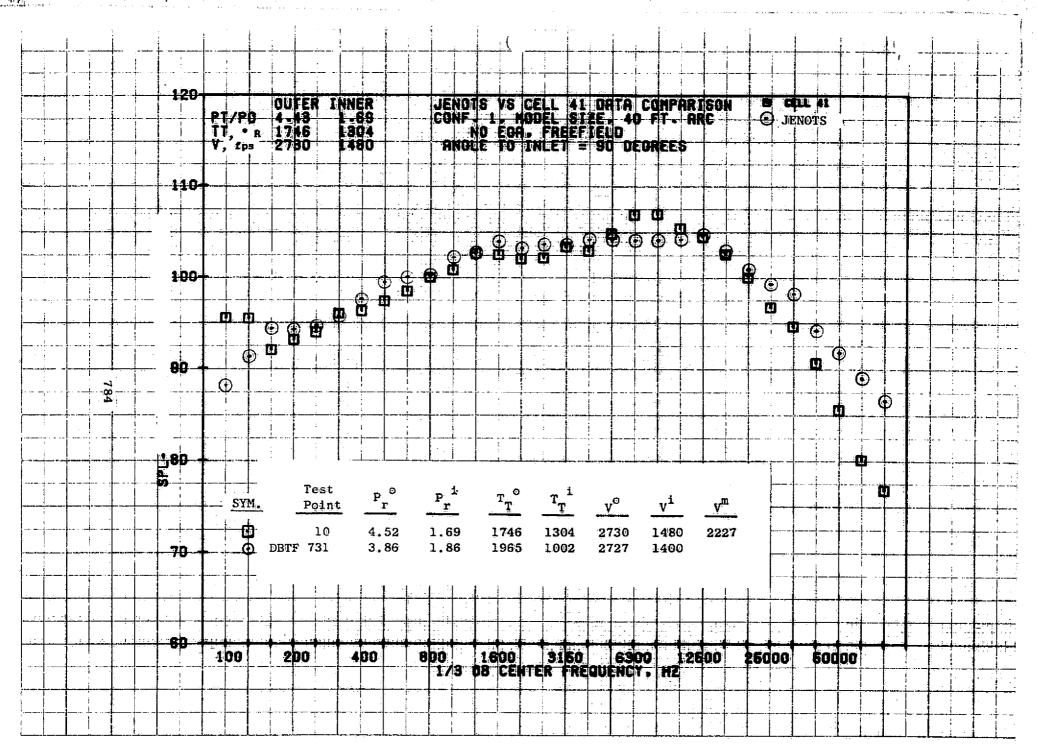
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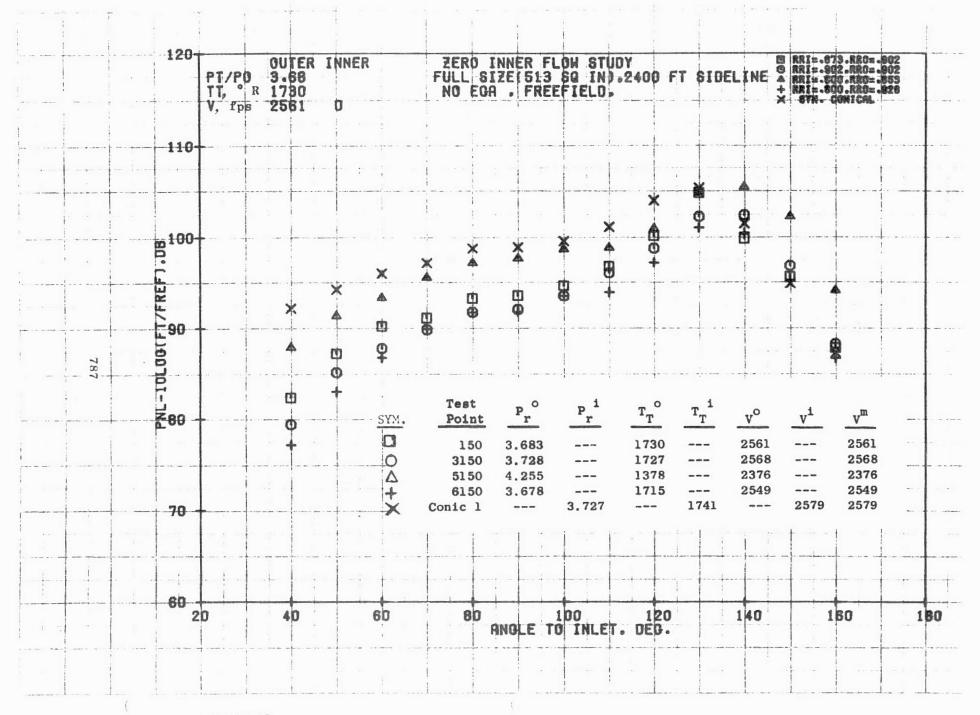


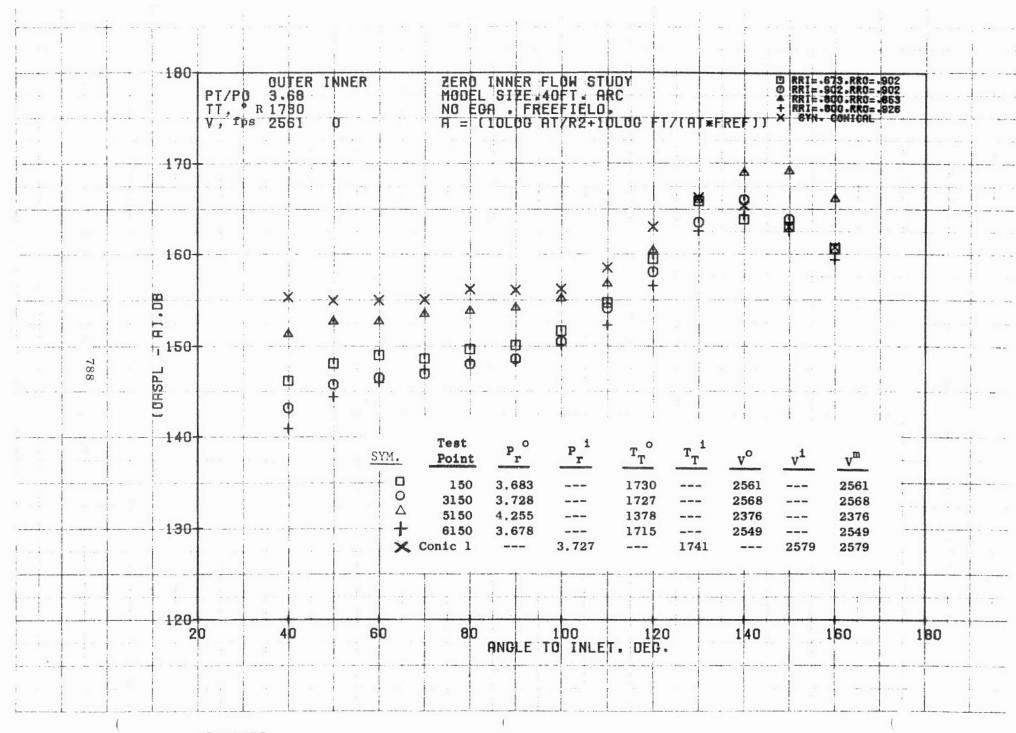
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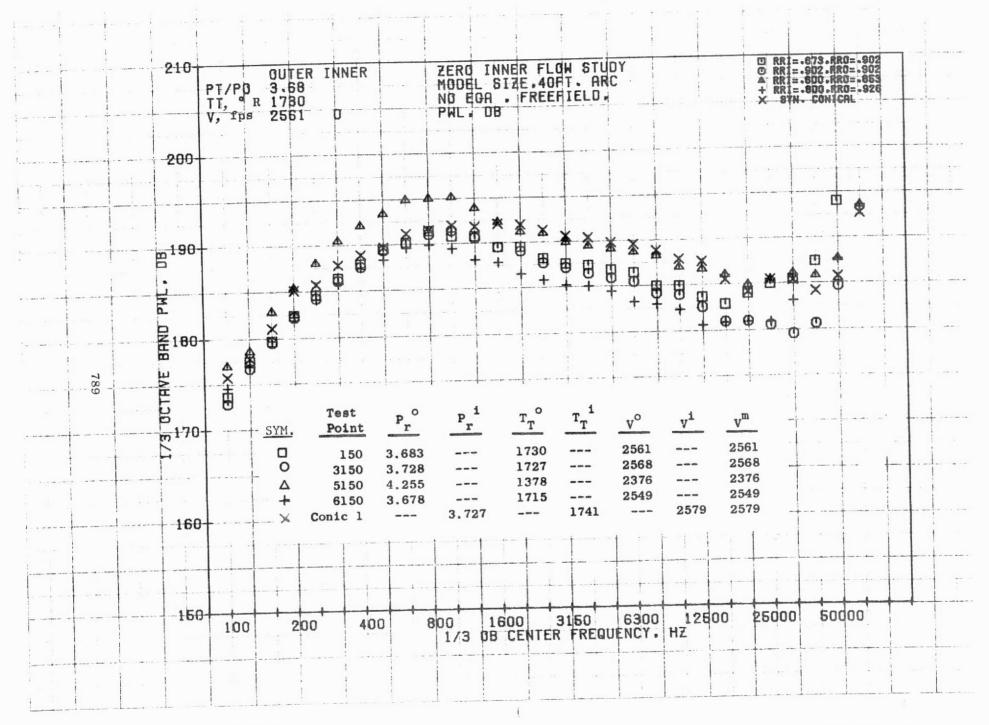
7.3 COMPARISON OF DATA FOR IVP NOZZLES WITH LOW AMOUNTS OF INNER FLOW

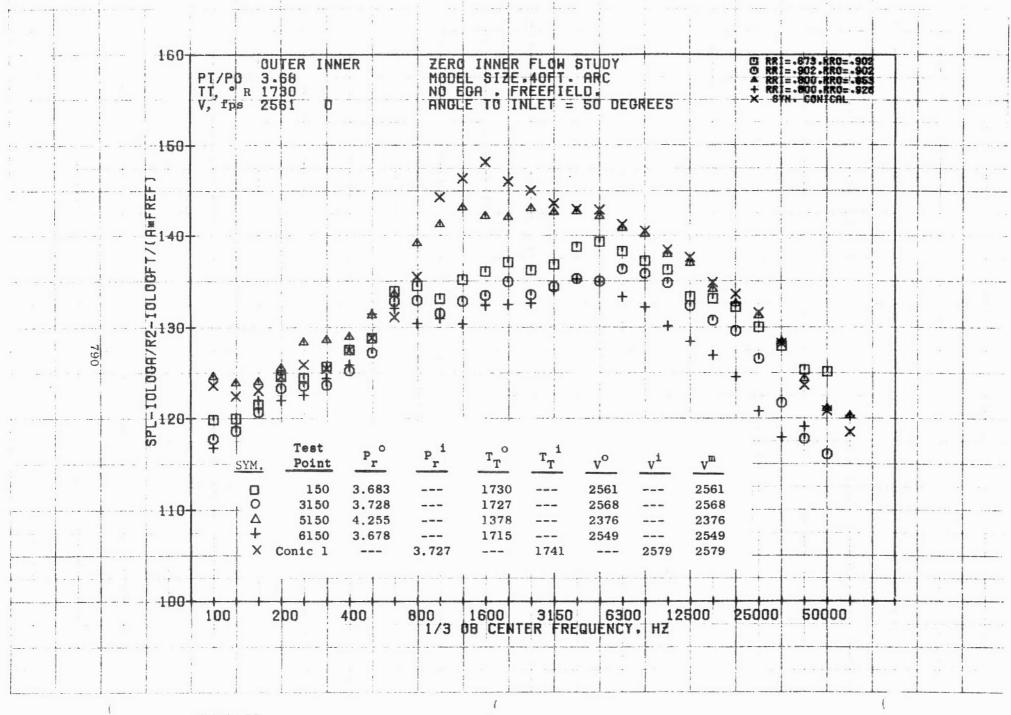
7.3.1 Zero Inner Flow Study

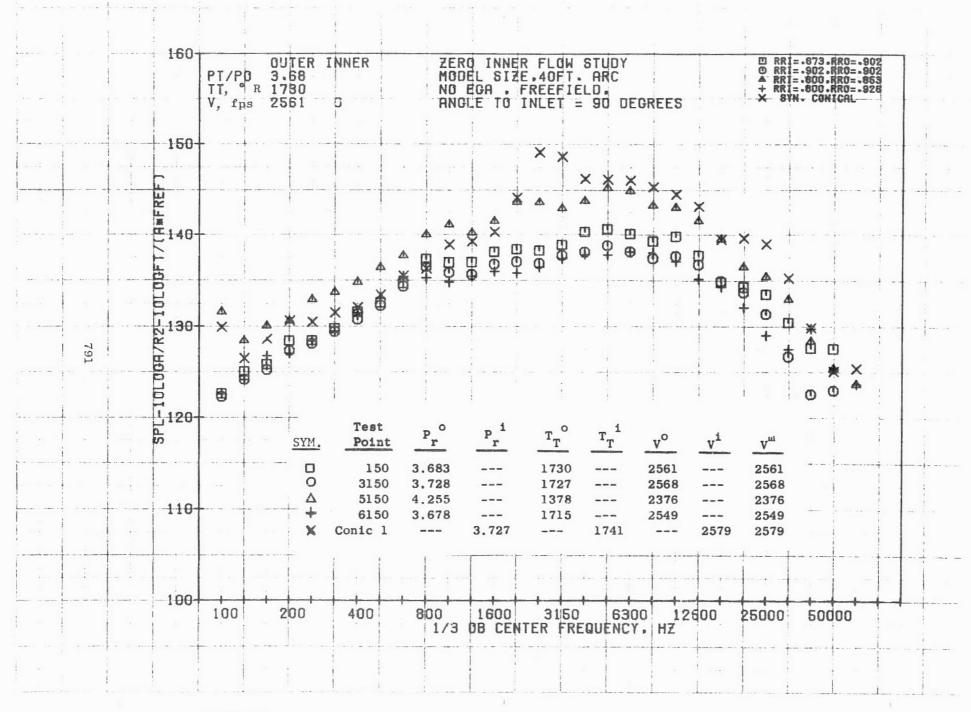
For configurations 1, 3, 5, and 6, acoustic measurements were made with no inner flow. For configurations 1 and 3 the outer radius ratio was 0.902 while for configurations 5 and 6, it was 0.853 and 0.926, respectively. The effect of the outer radius ratio on noise levels with zero inner flow is demonstrated in the following plots.

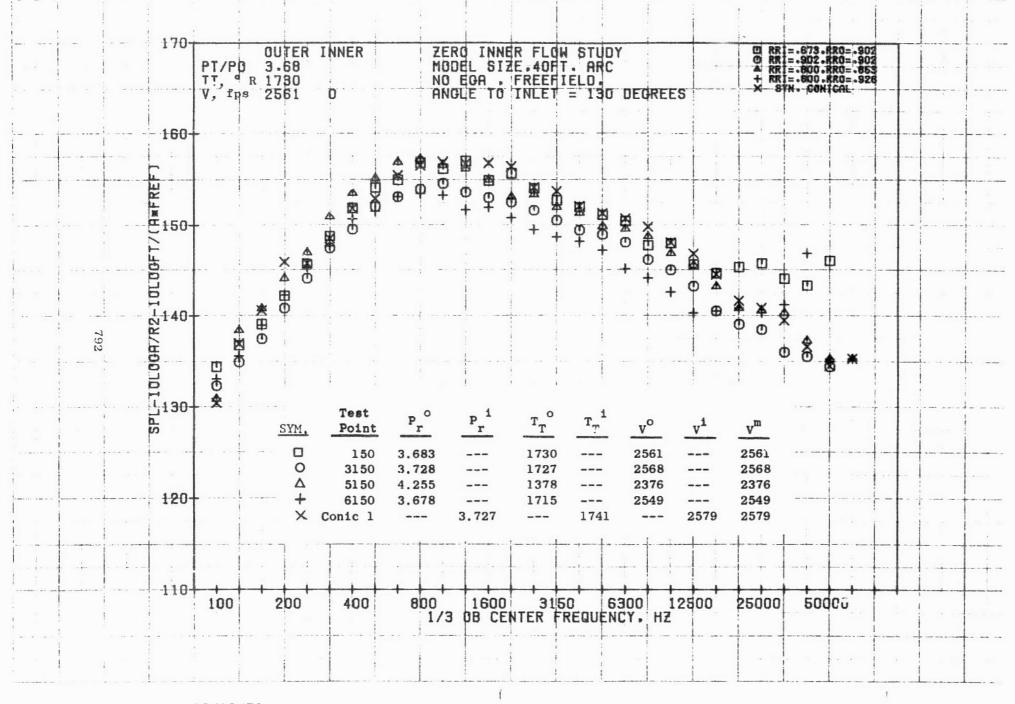


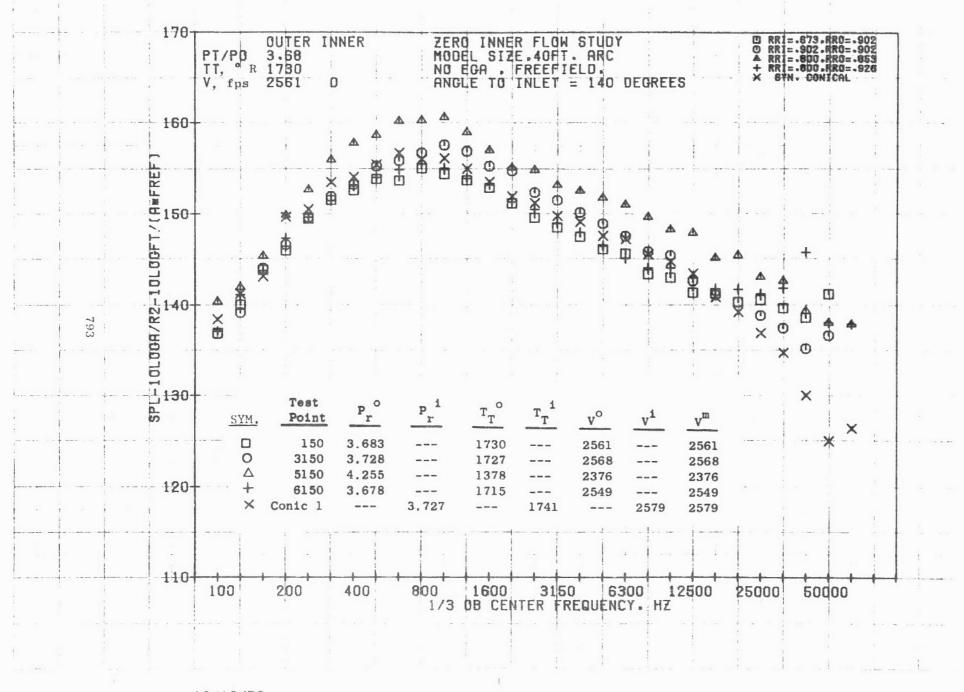


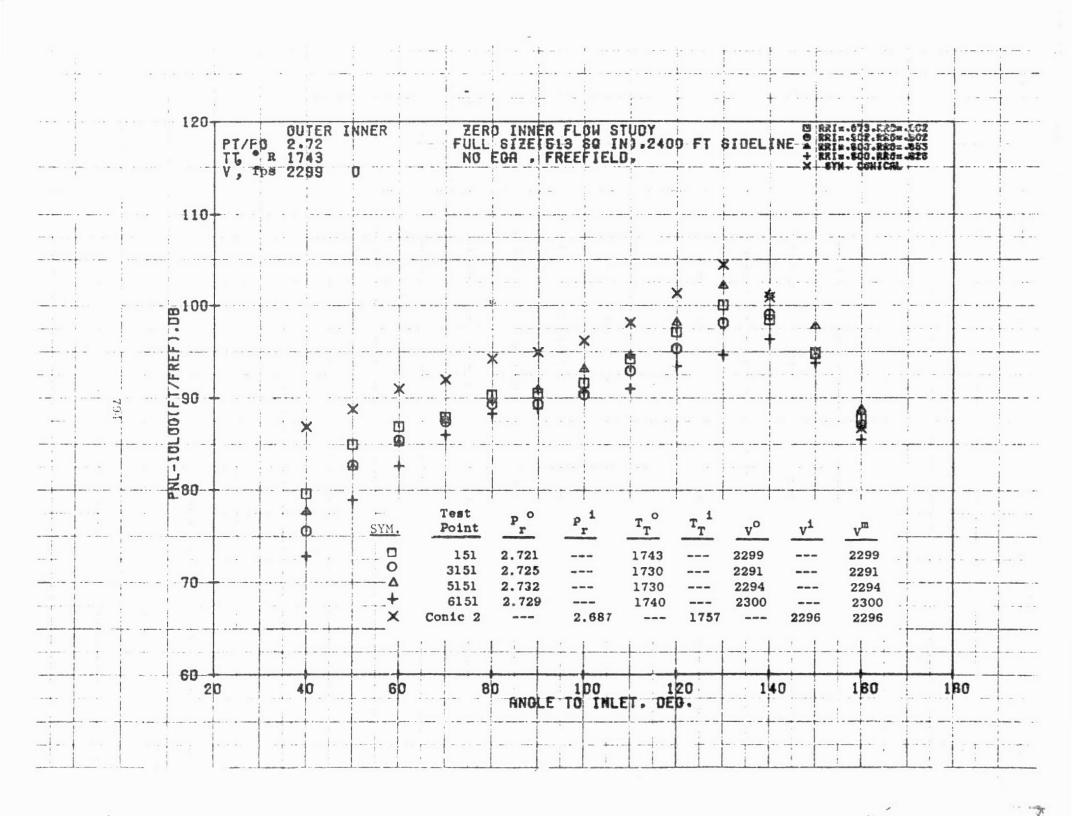


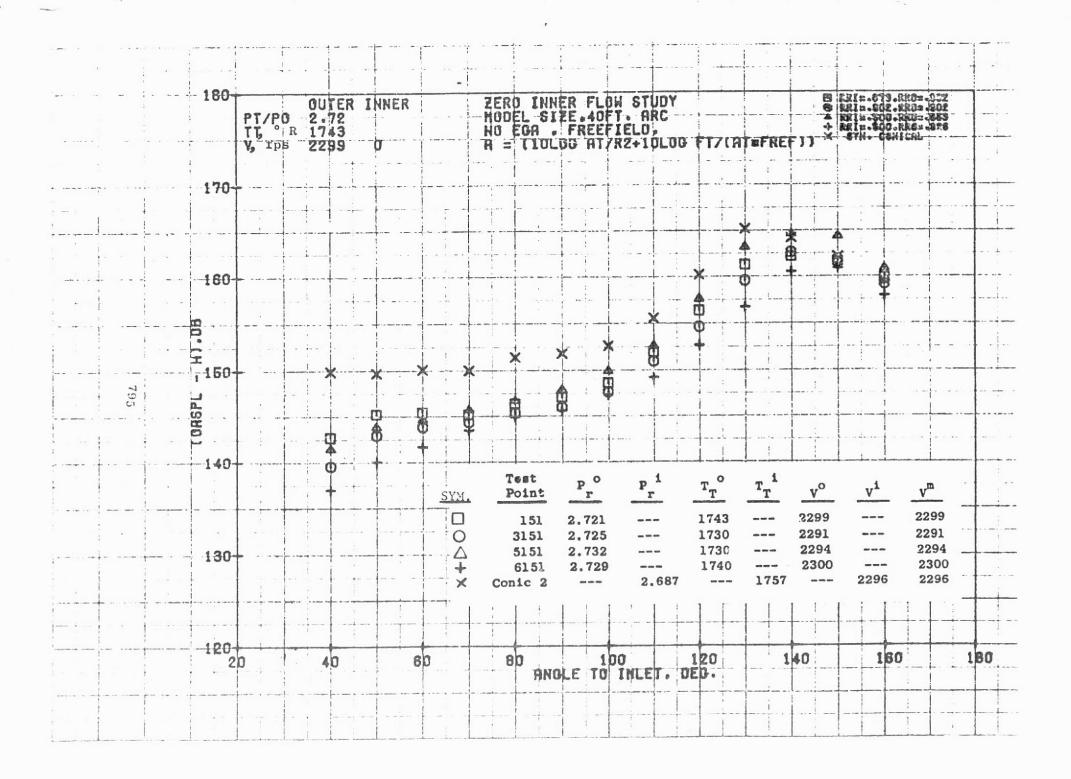


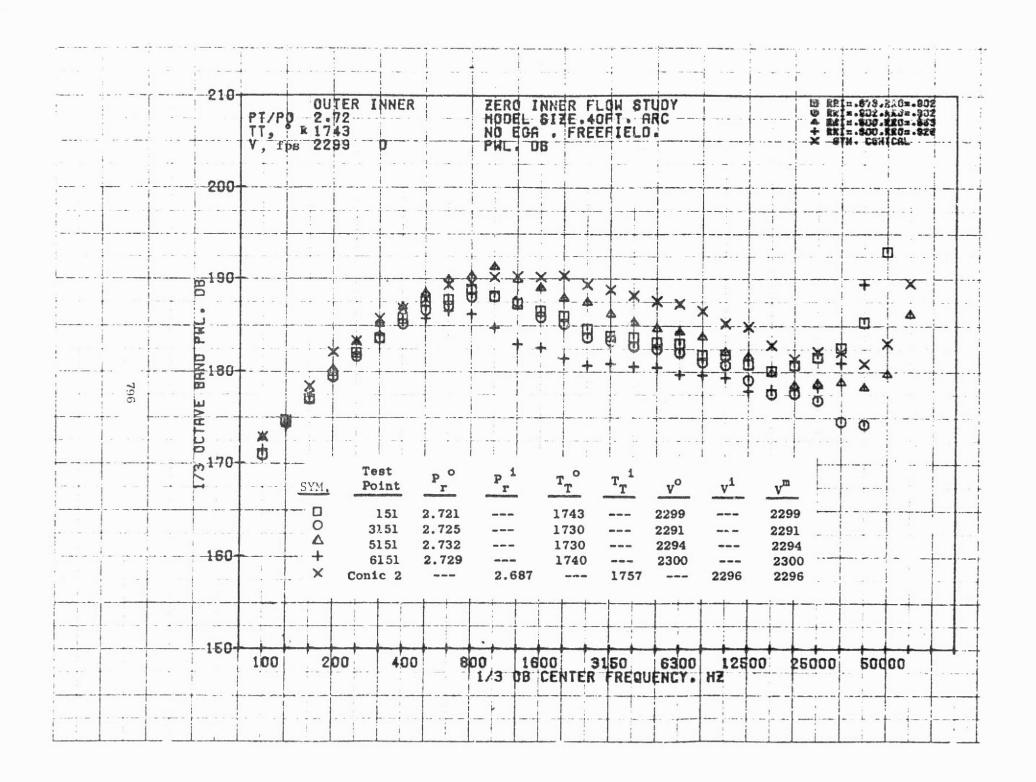


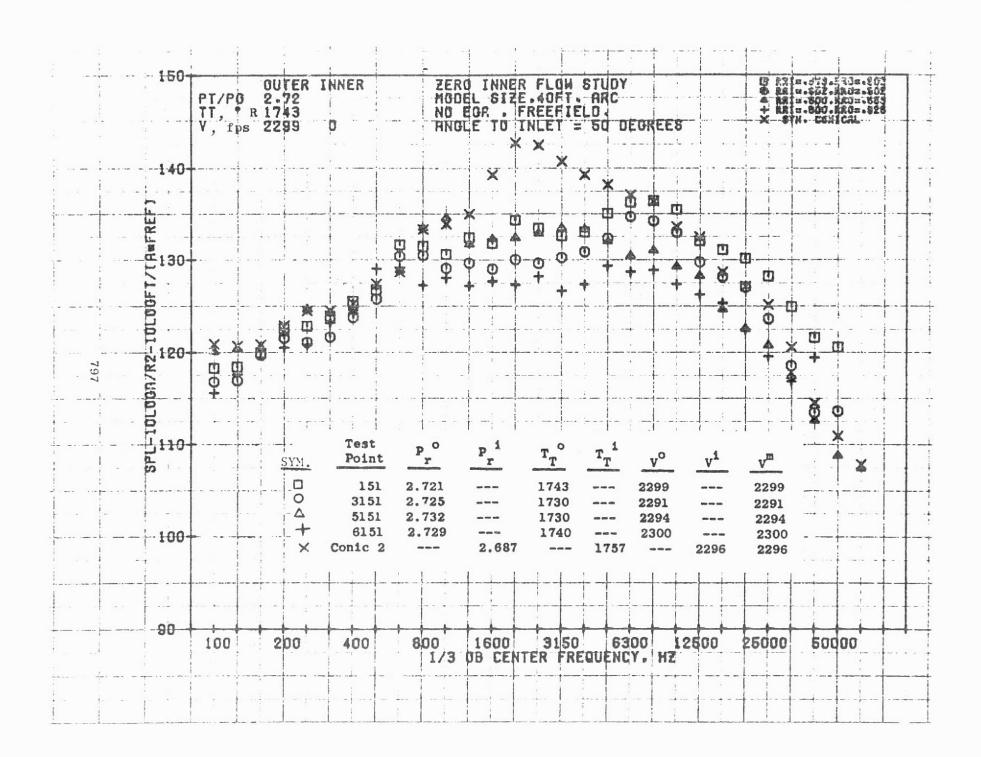




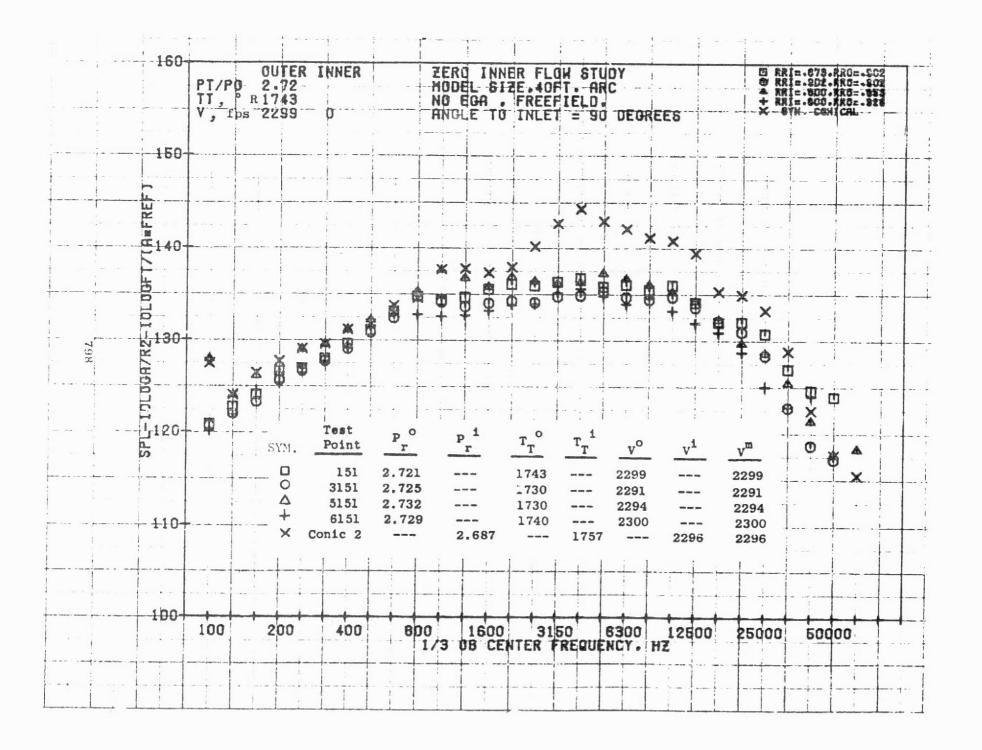


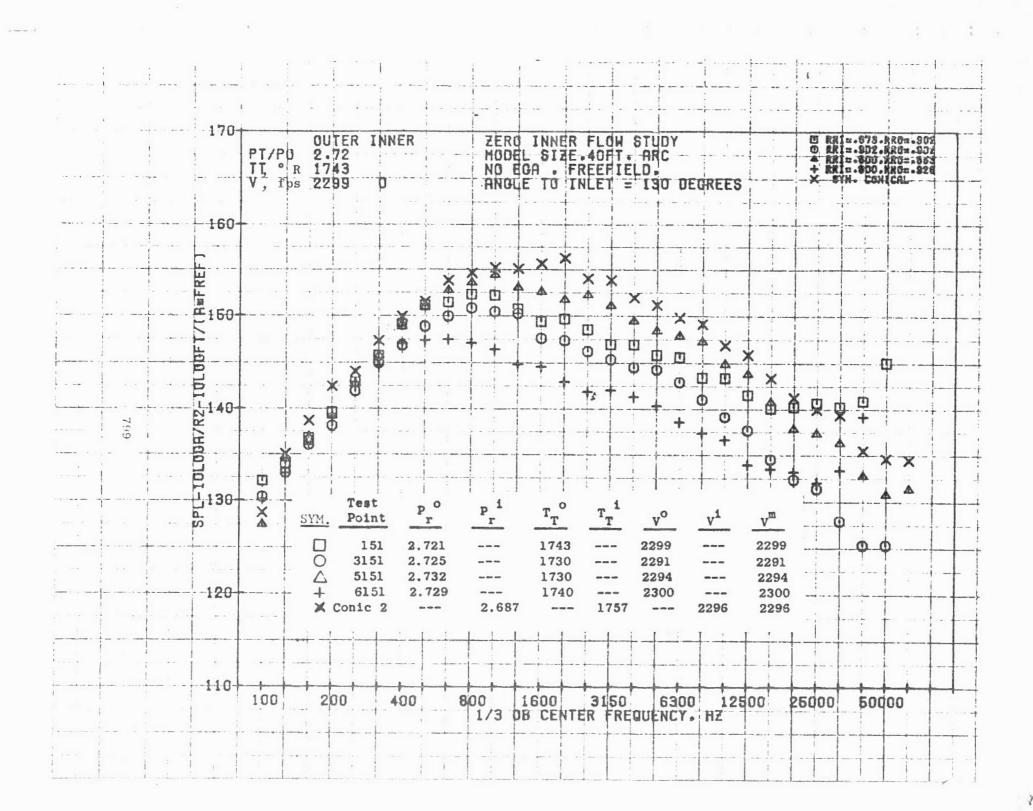


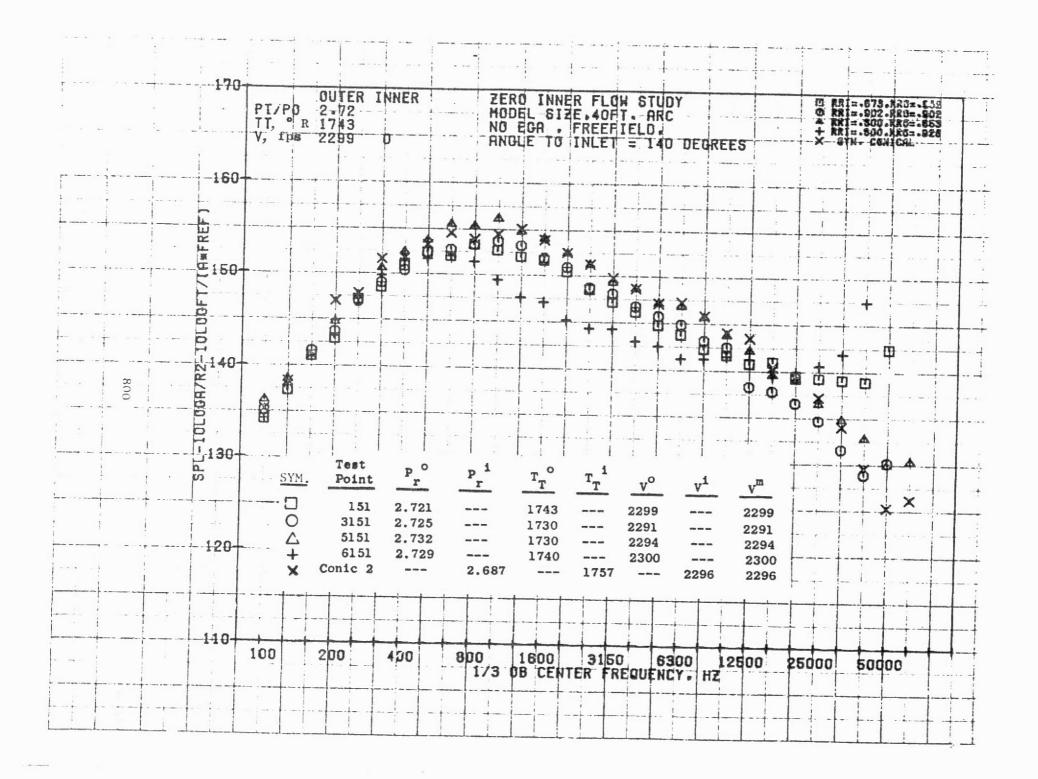


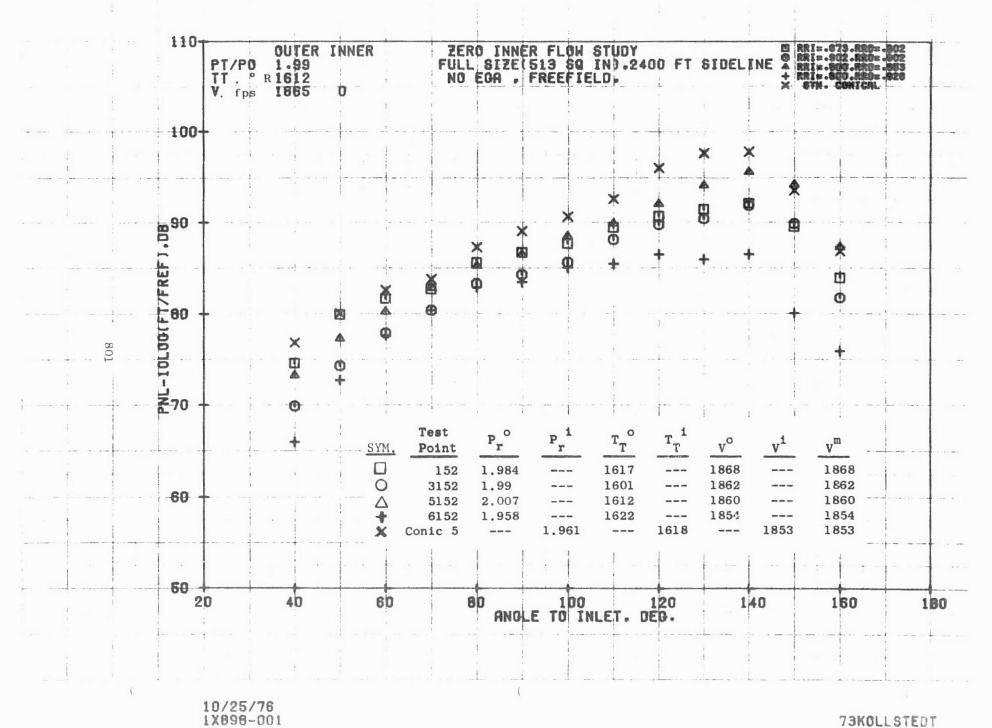


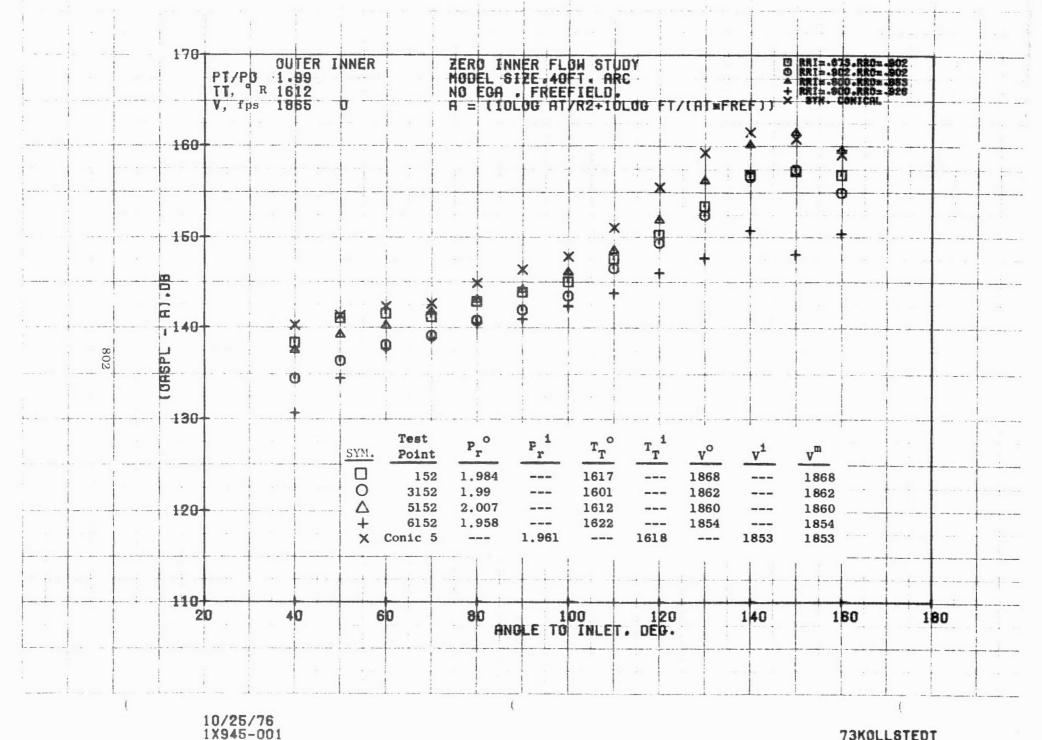
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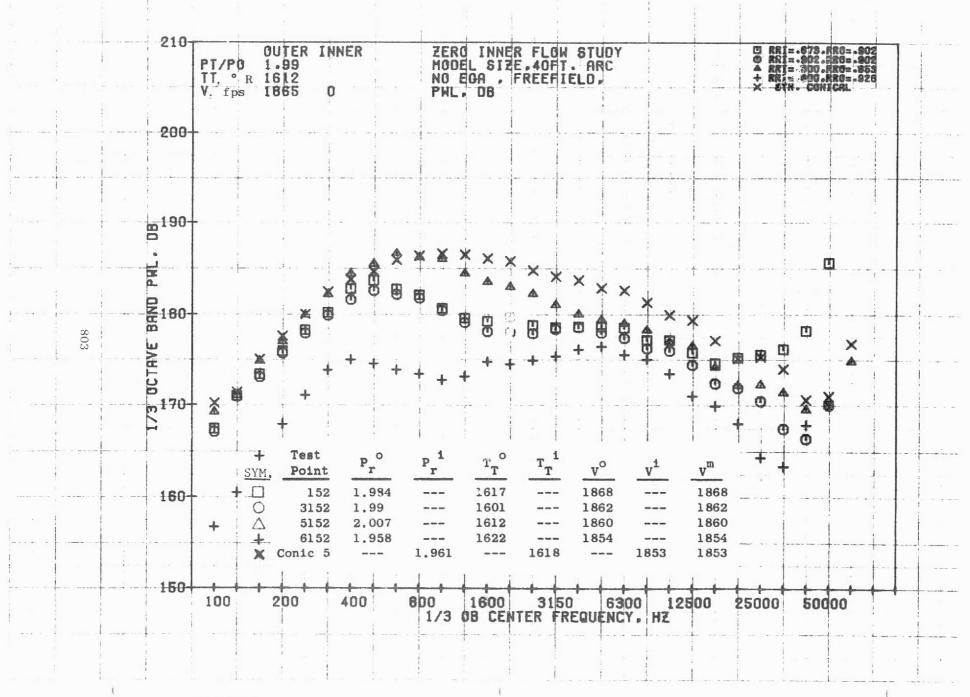


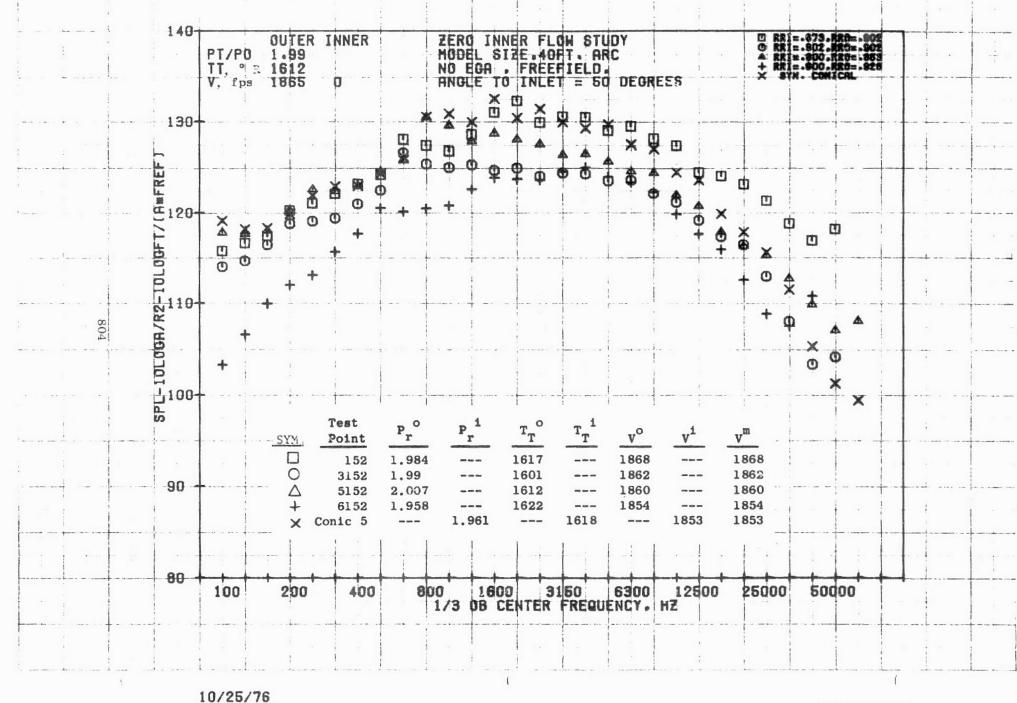




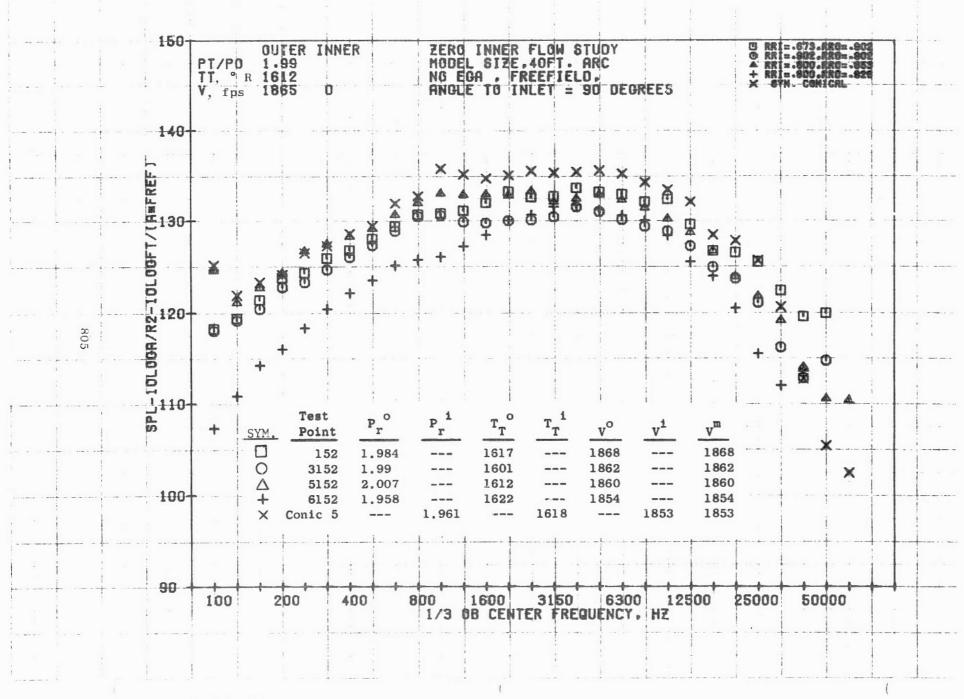


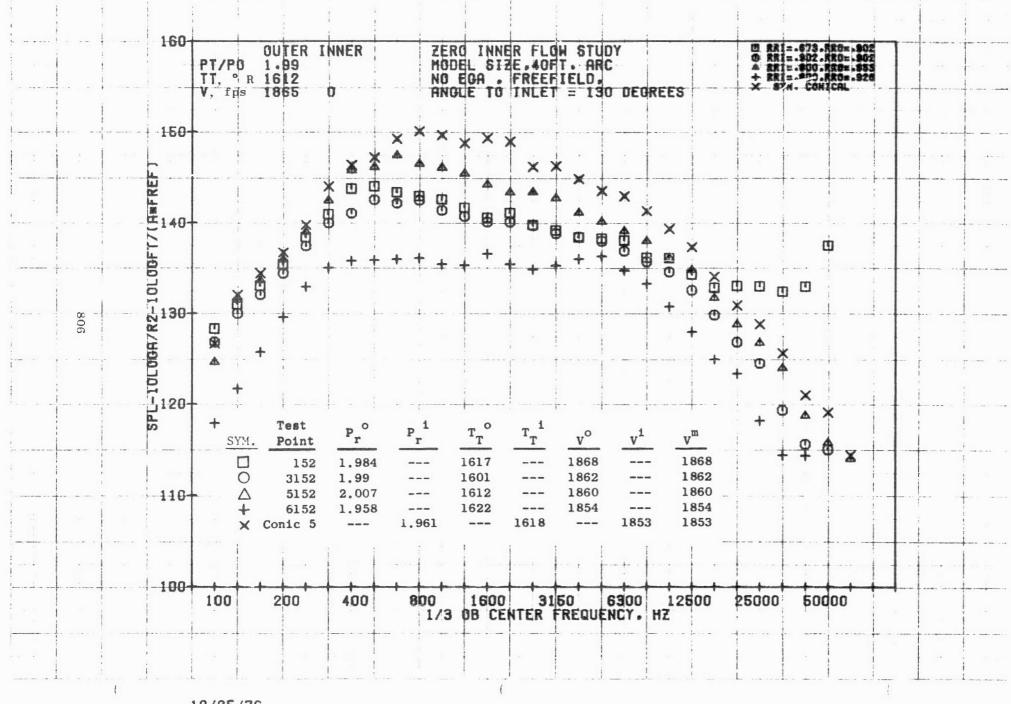


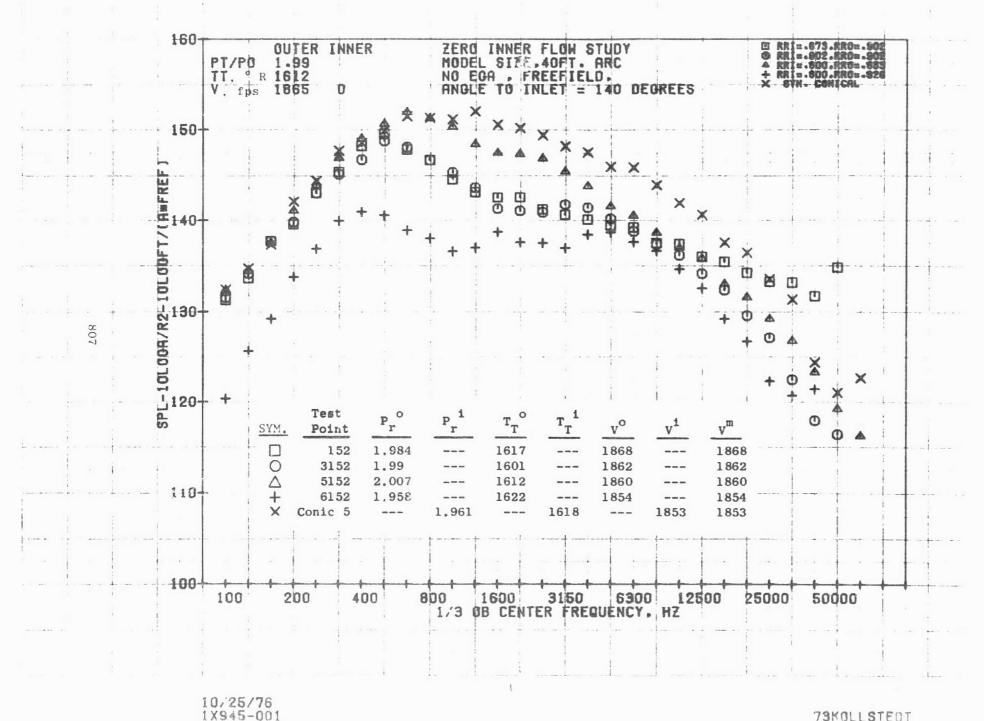




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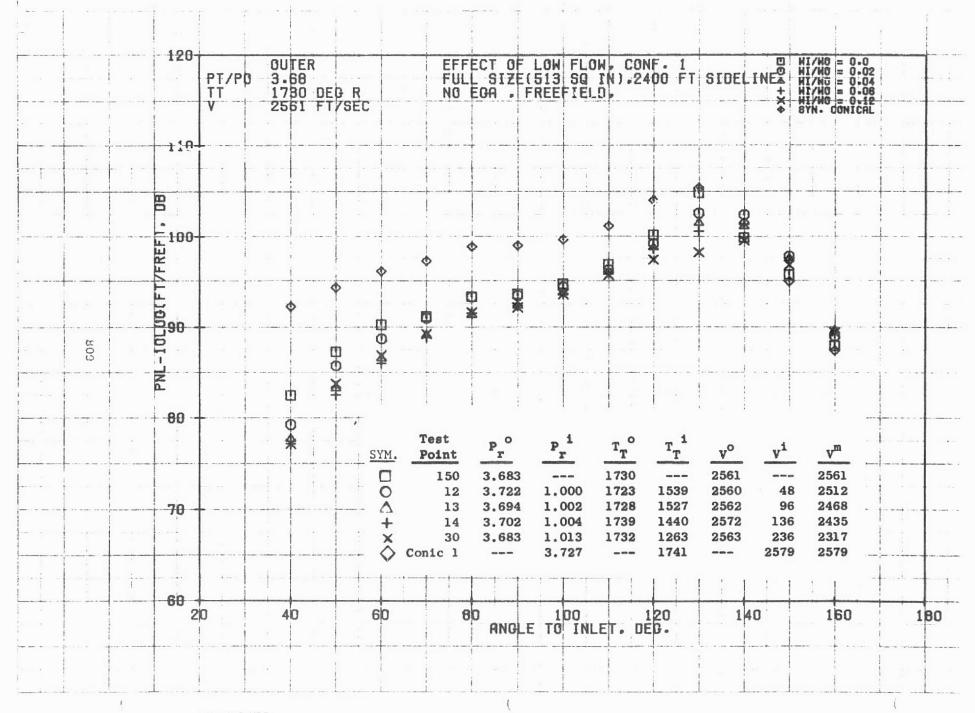


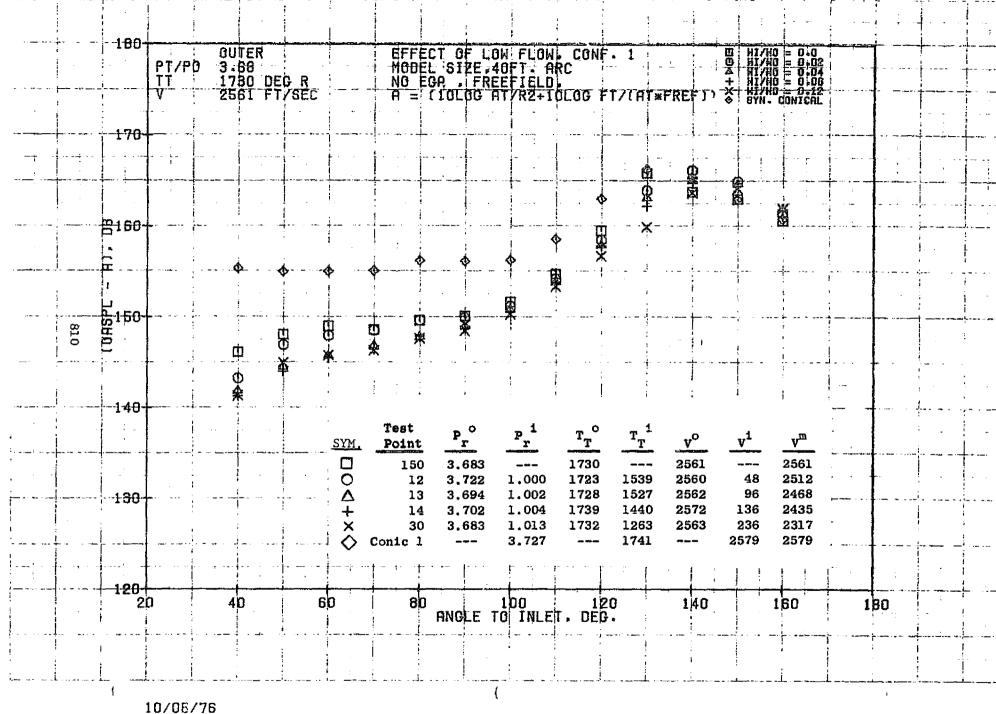
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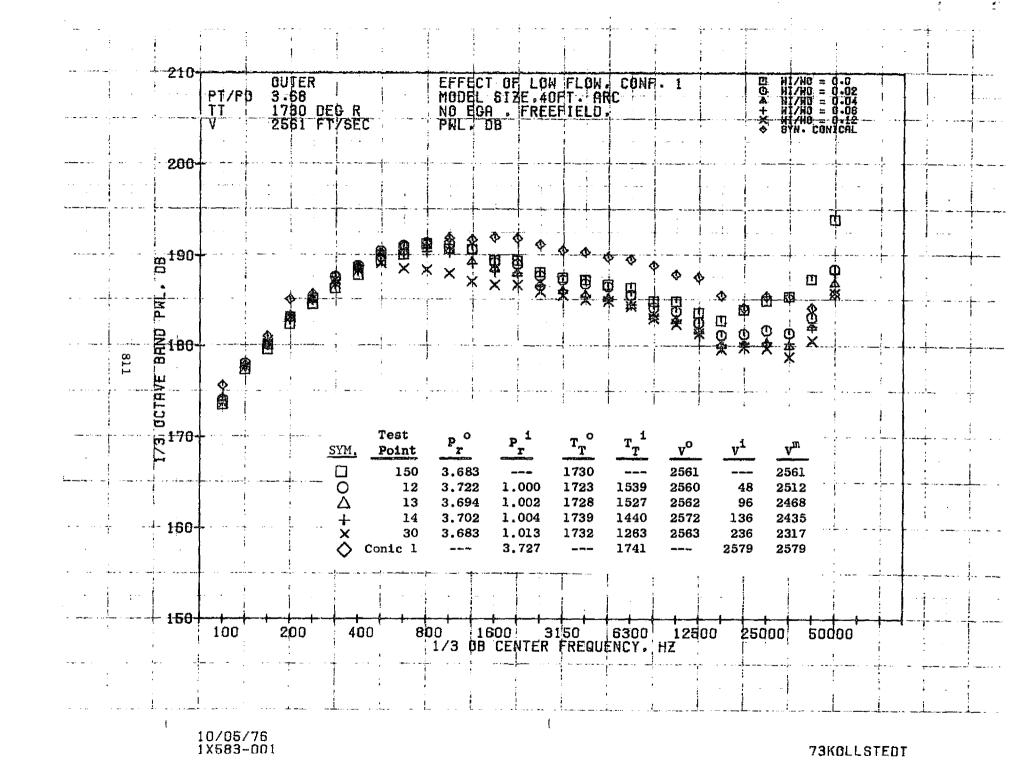
7.3.2 Low Inner Flow Study

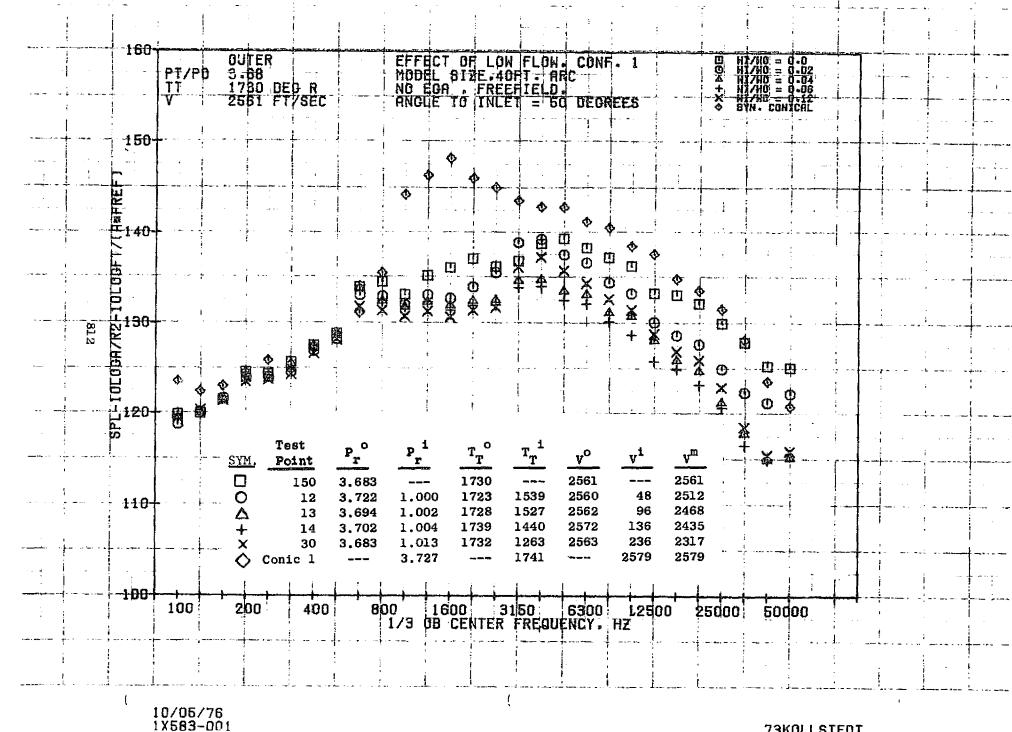
The effect of low inner flows was investigated for configurations 1 and 3. Configurations 1 and 3 both have a 0.902 outer radius ratio, but configuration 1 has a 0.673 inner radius ratio compared to a 0.902 inner radius ratio for configuration 3. Low flow testing was initially performed on configuration 1 at weight flow ratios (W^1/W^0) of 0.02, 0.04, and 0.06. It was found that there was no significant noise suppression relative to the zero inner flow case so higher inner flow rates were tested. Noise suppression was seen at higher flow rates so that for configuration 3 the tests were performed primarily at weight flow ratios of 0.06, 0.09, and 0.12.

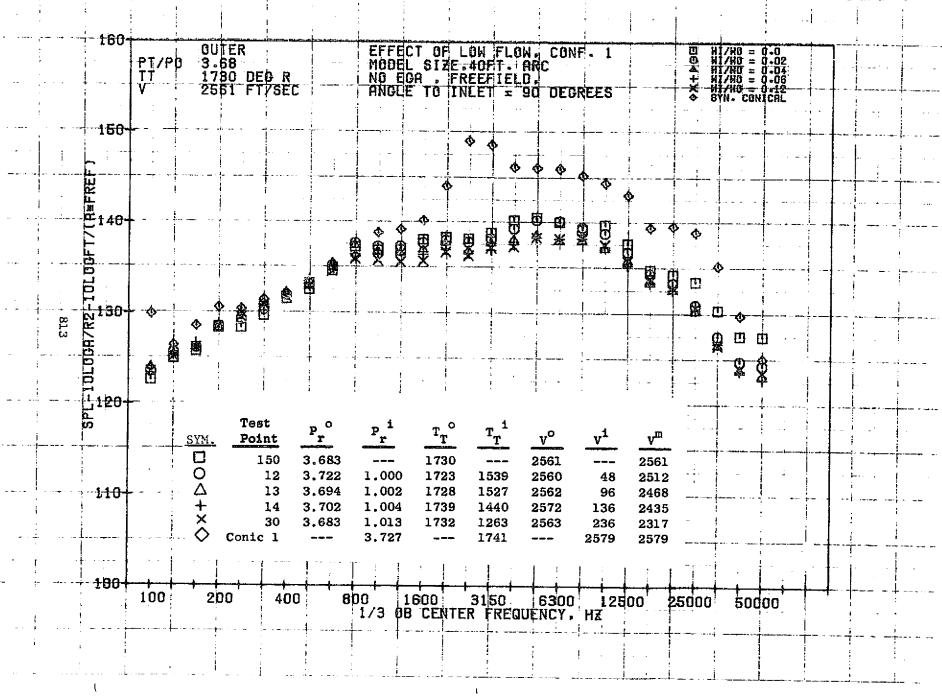
The following graphs are based on a variation of Wⁱ/W^O (sometimes expressed as W₈/W₂₈) whereas the Tables 6 and 7 in Volume I used Wⁱ/W_T and W^O/W_T parameters.





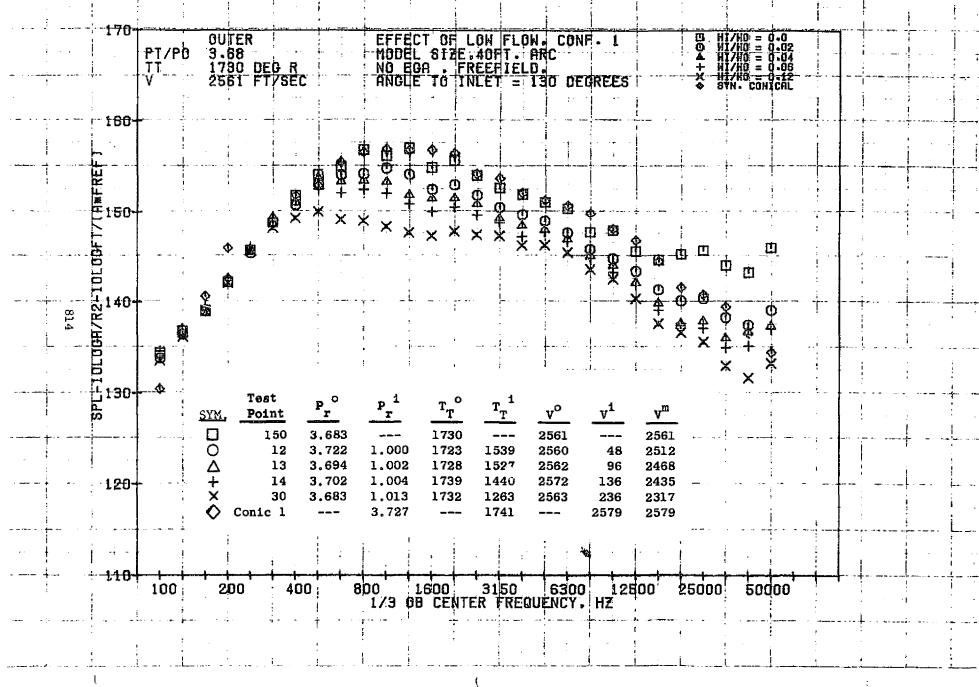


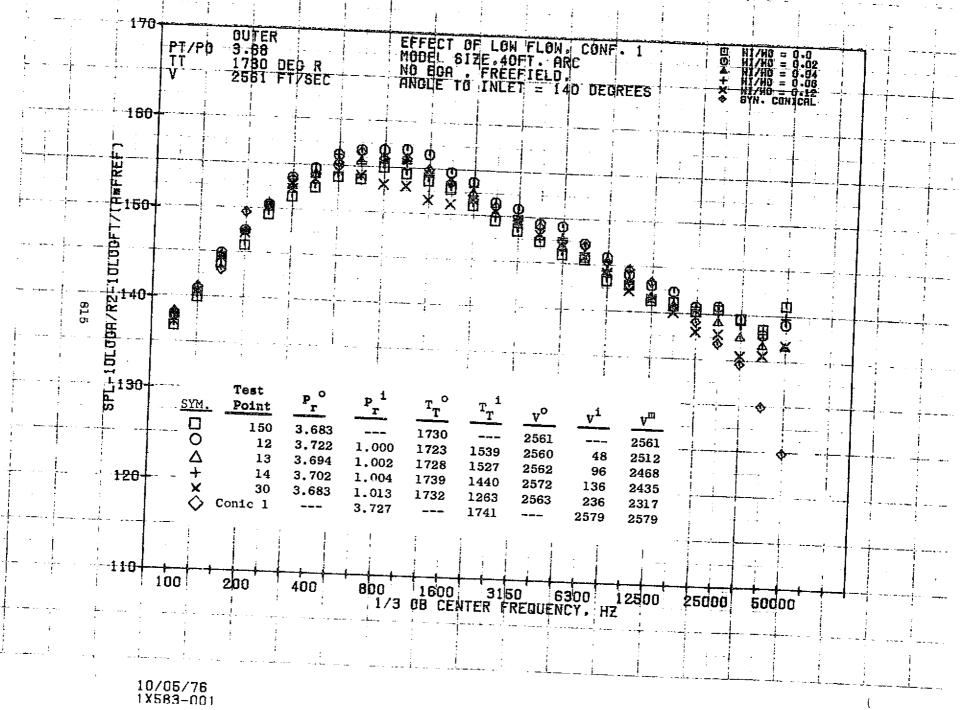


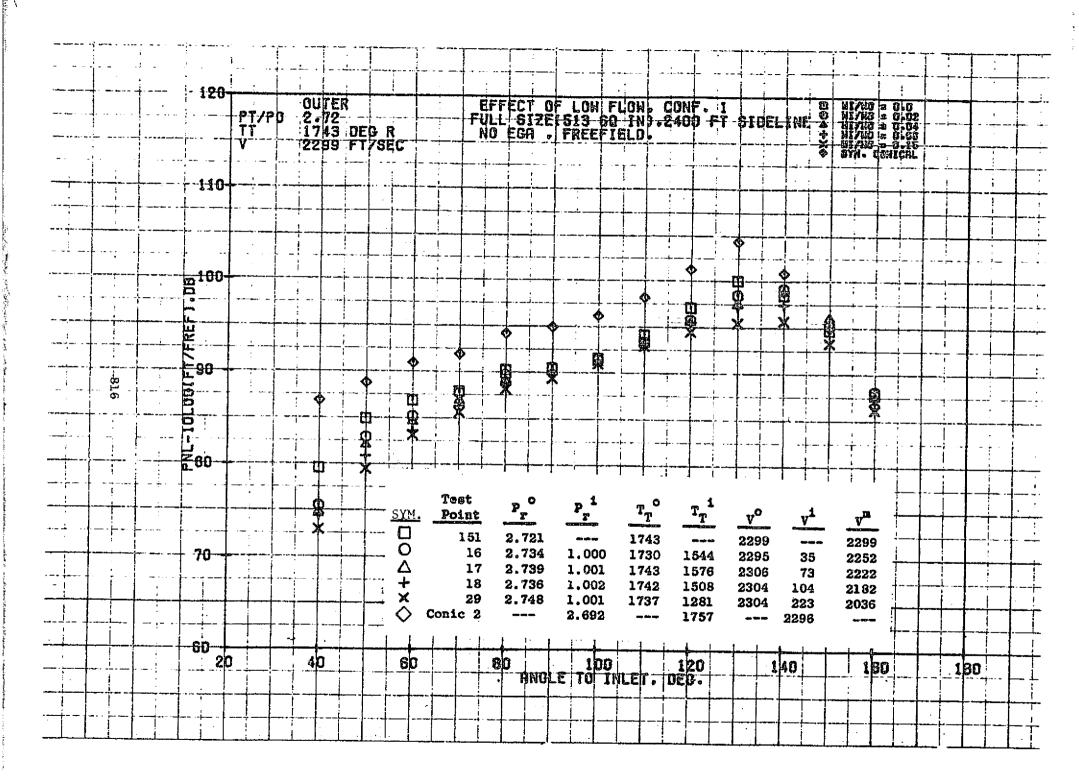


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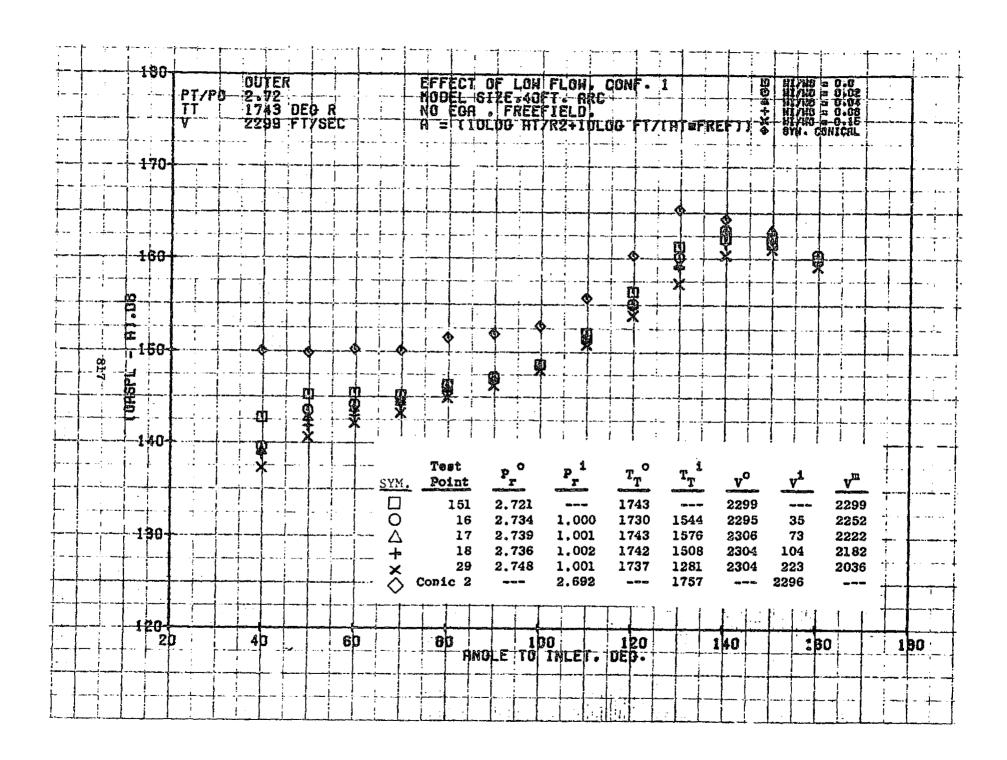
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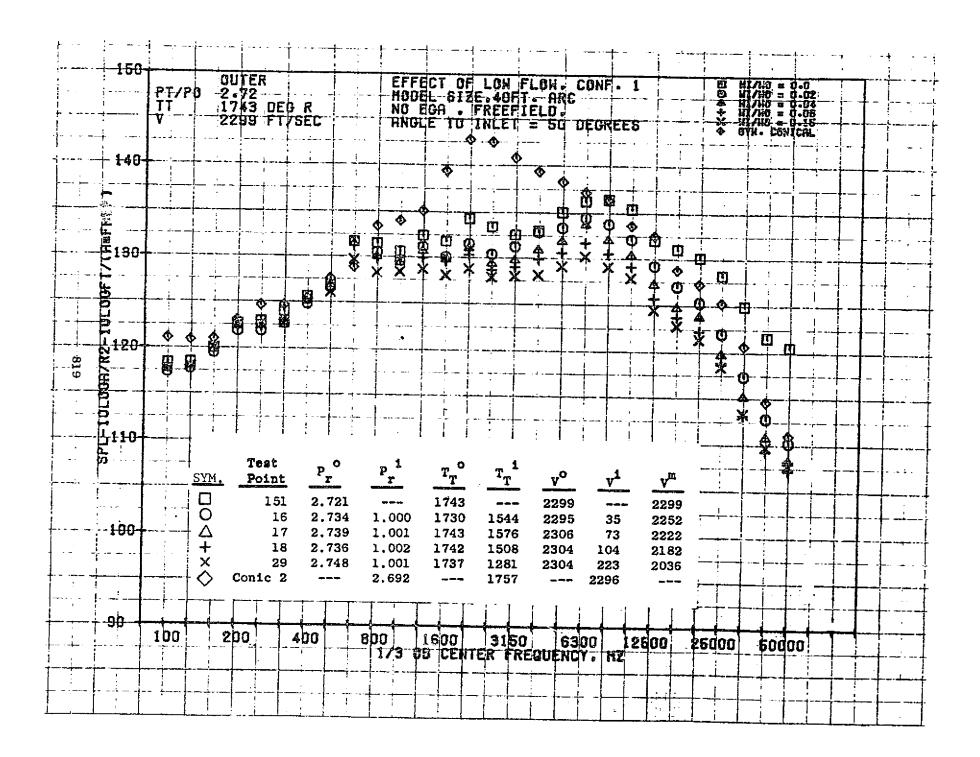
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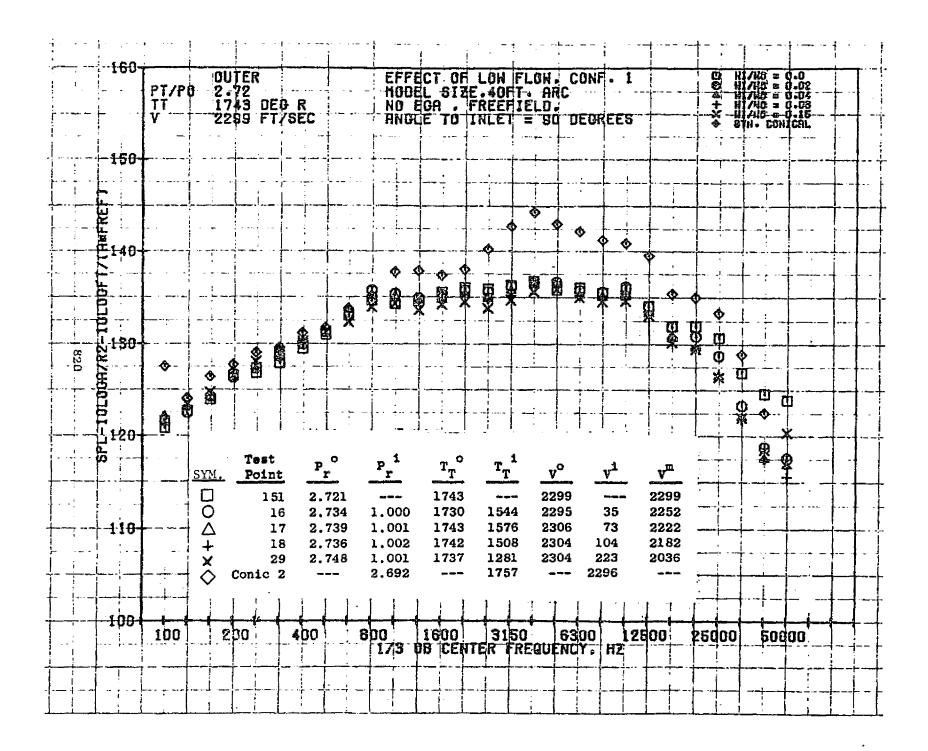


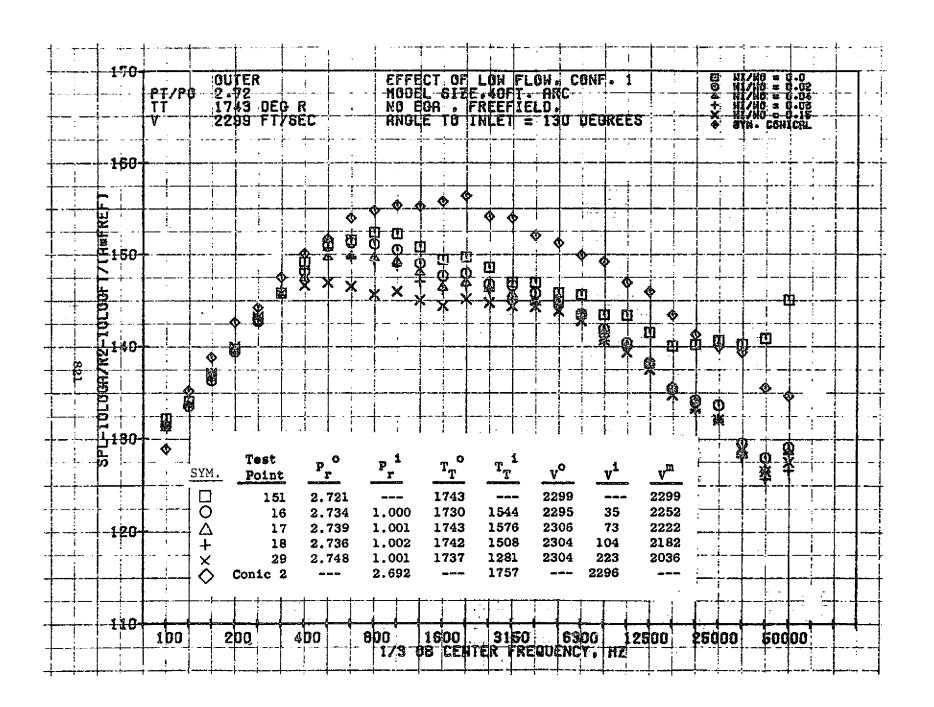
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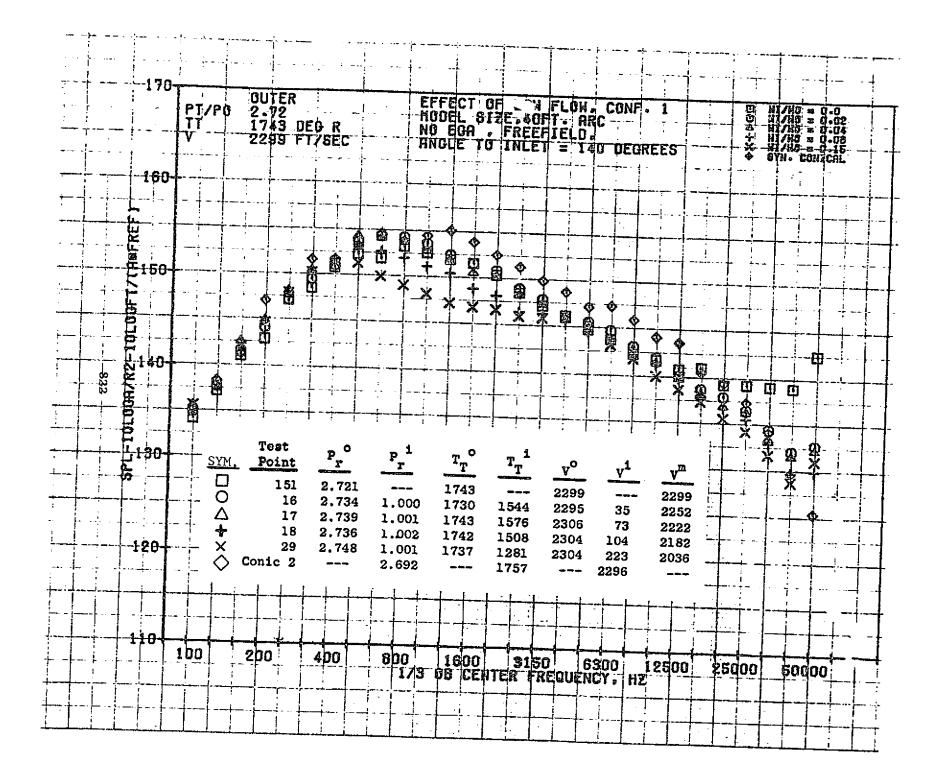
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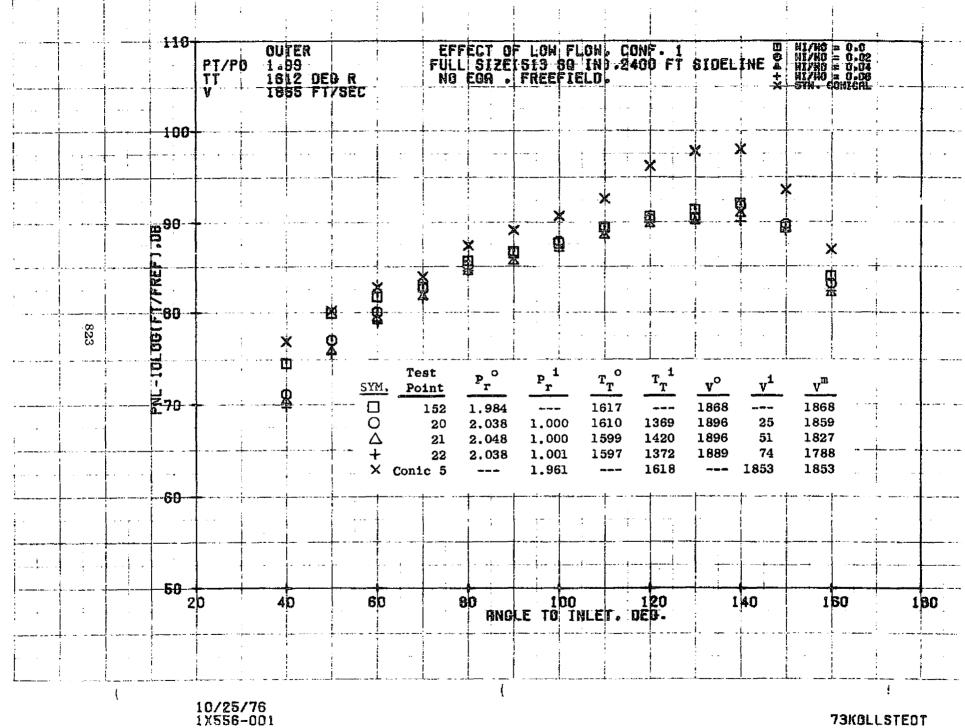


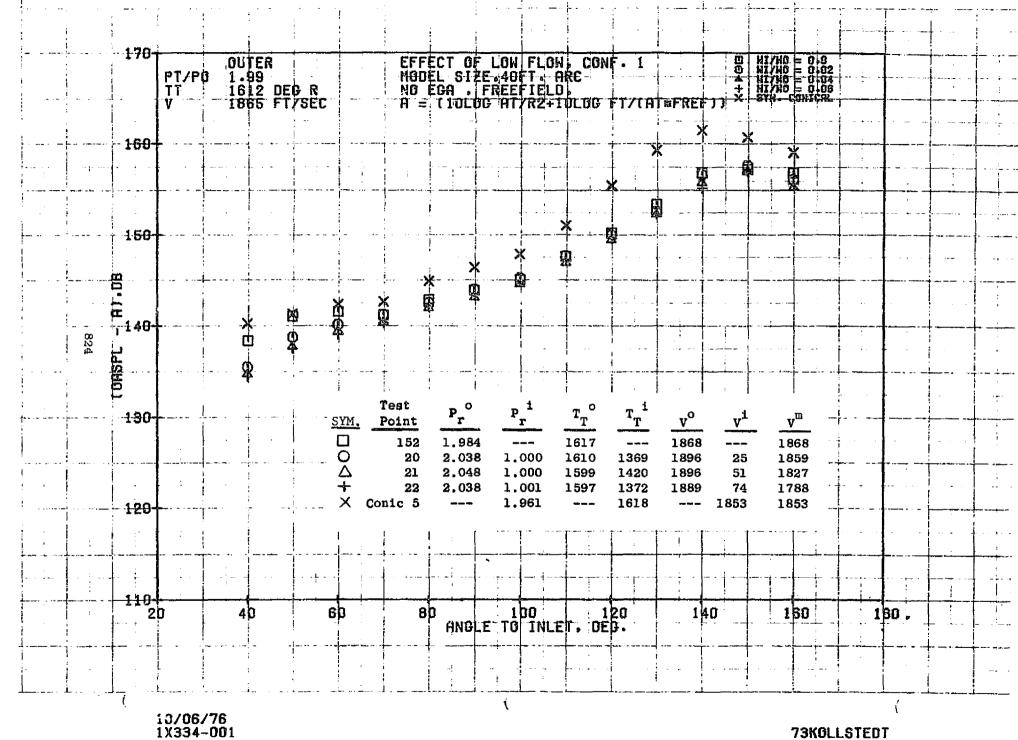


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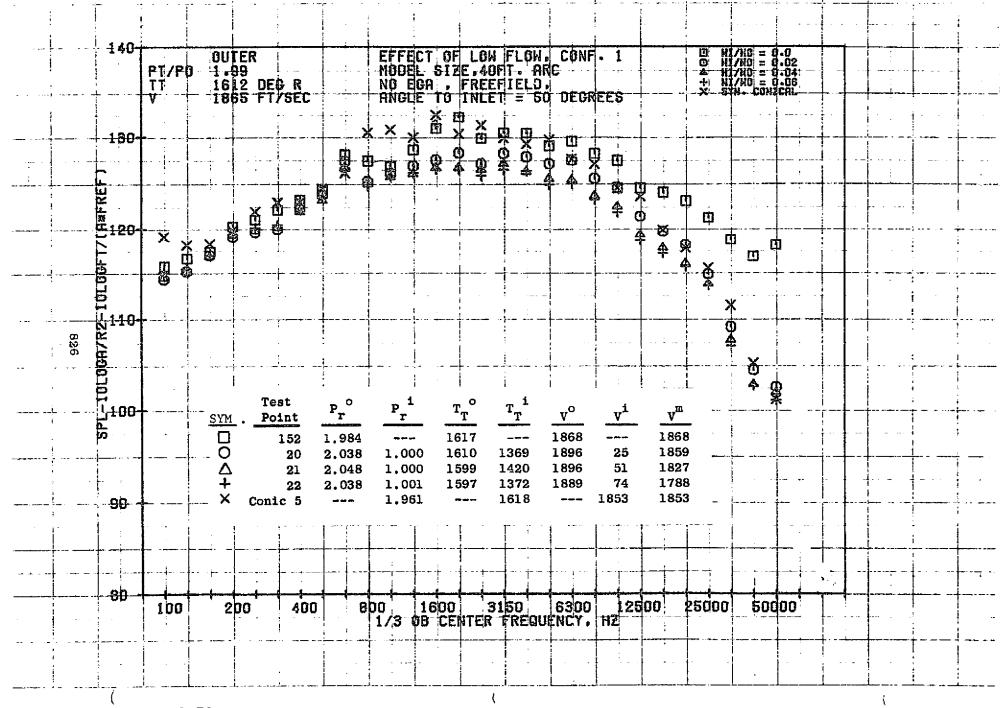


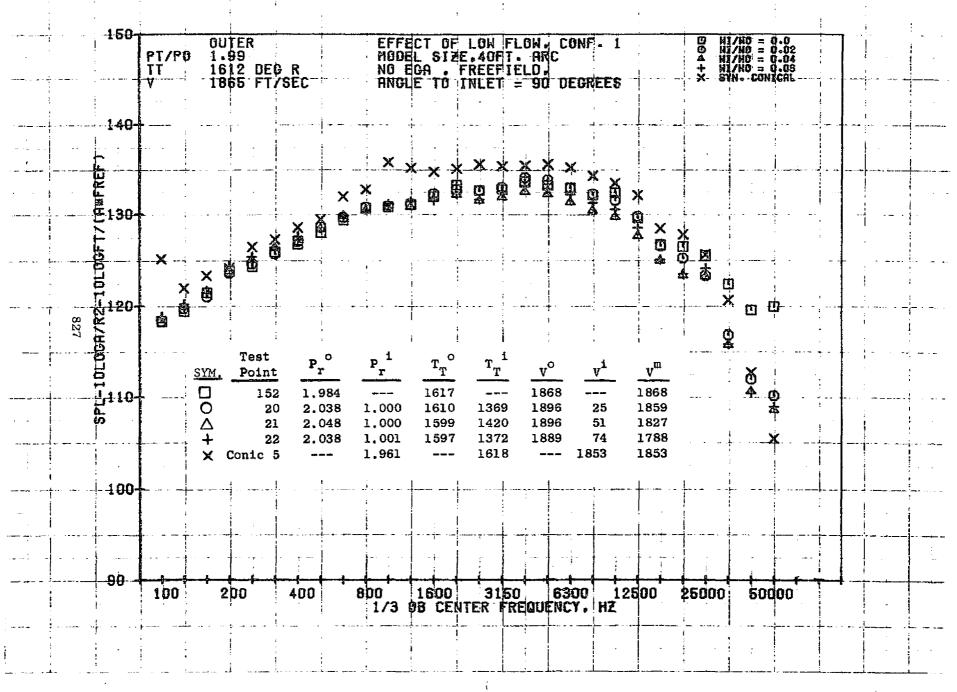
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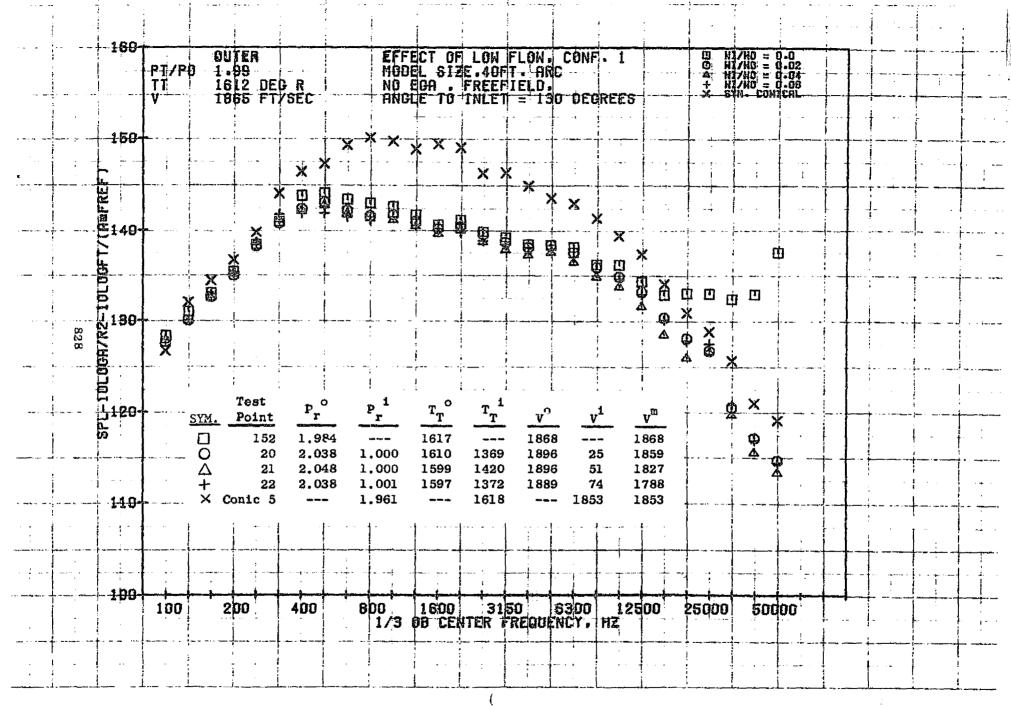


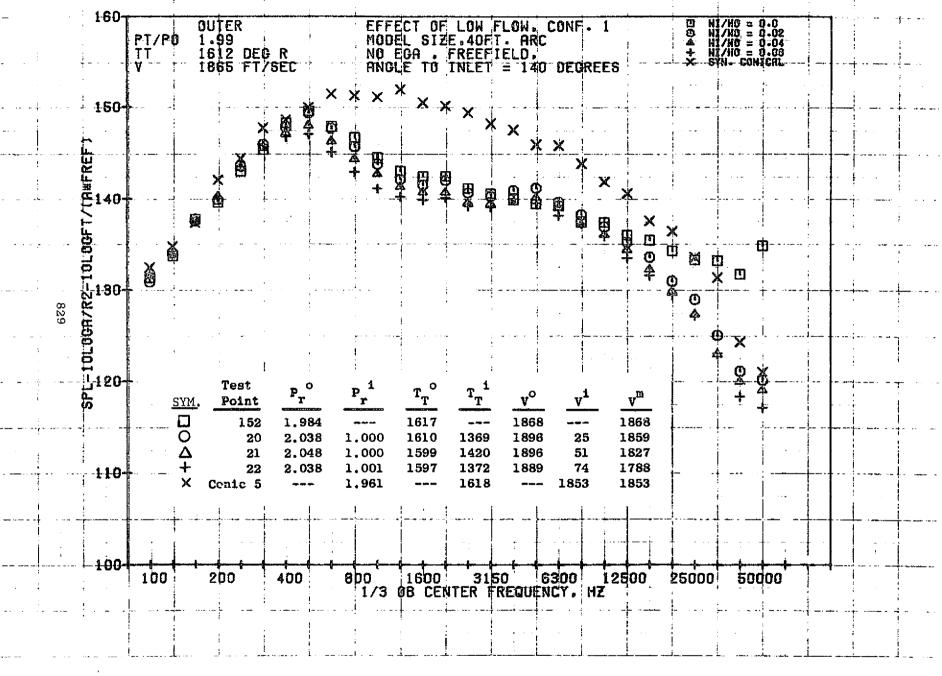
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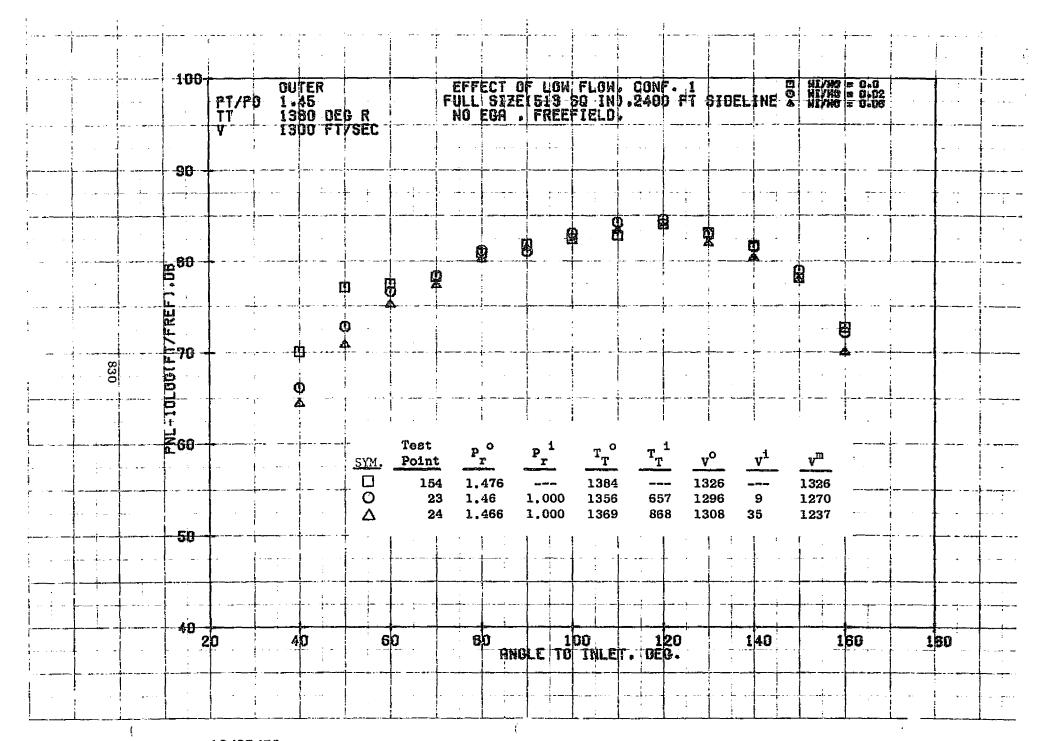




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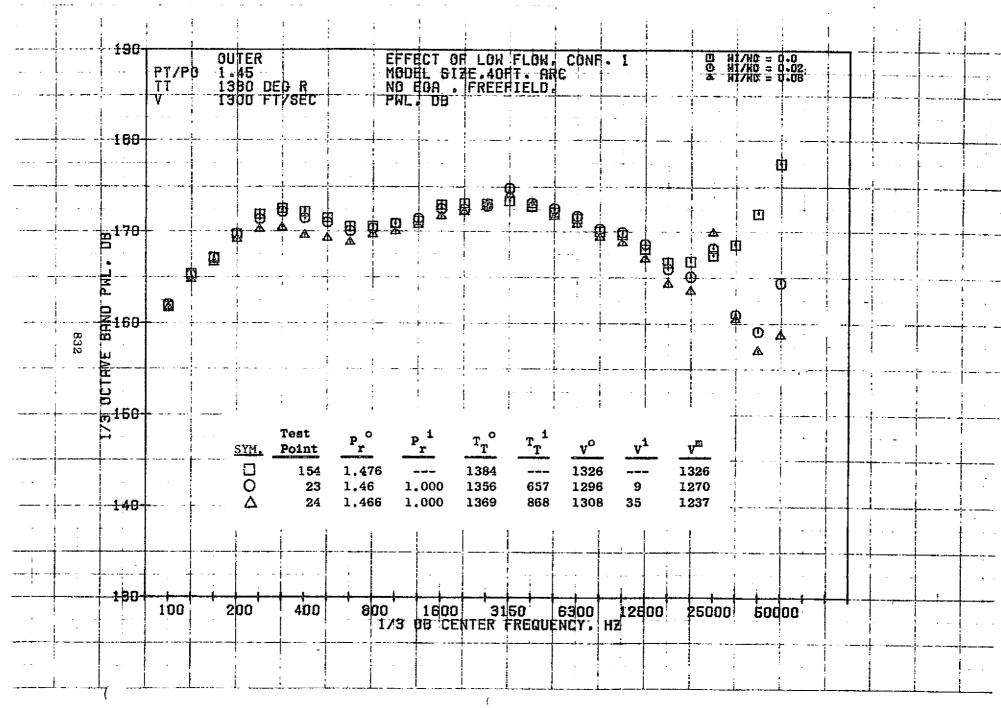


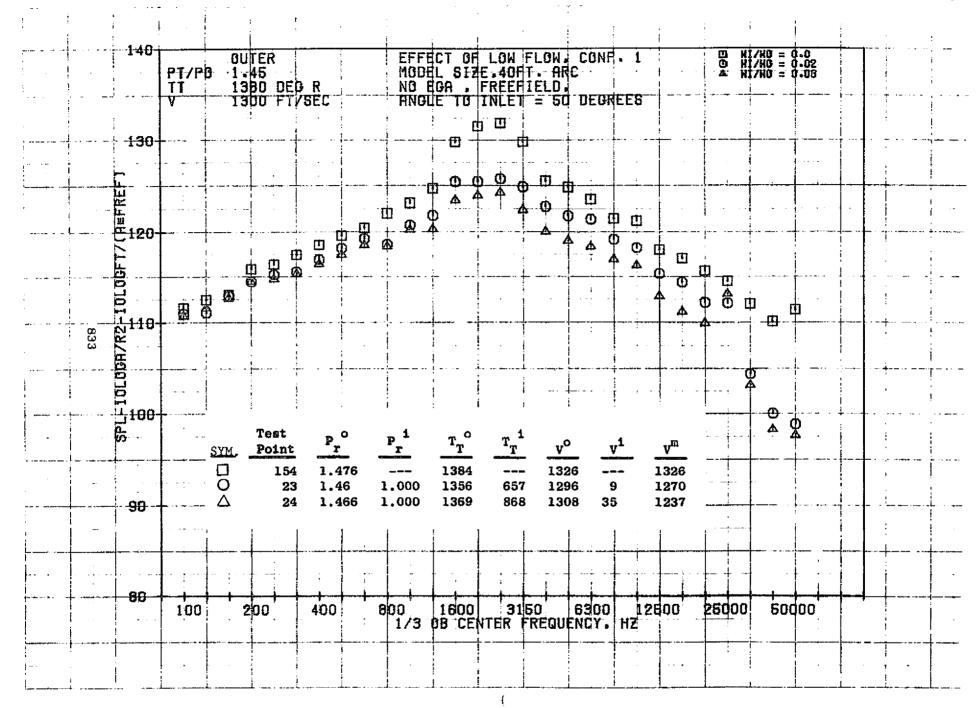




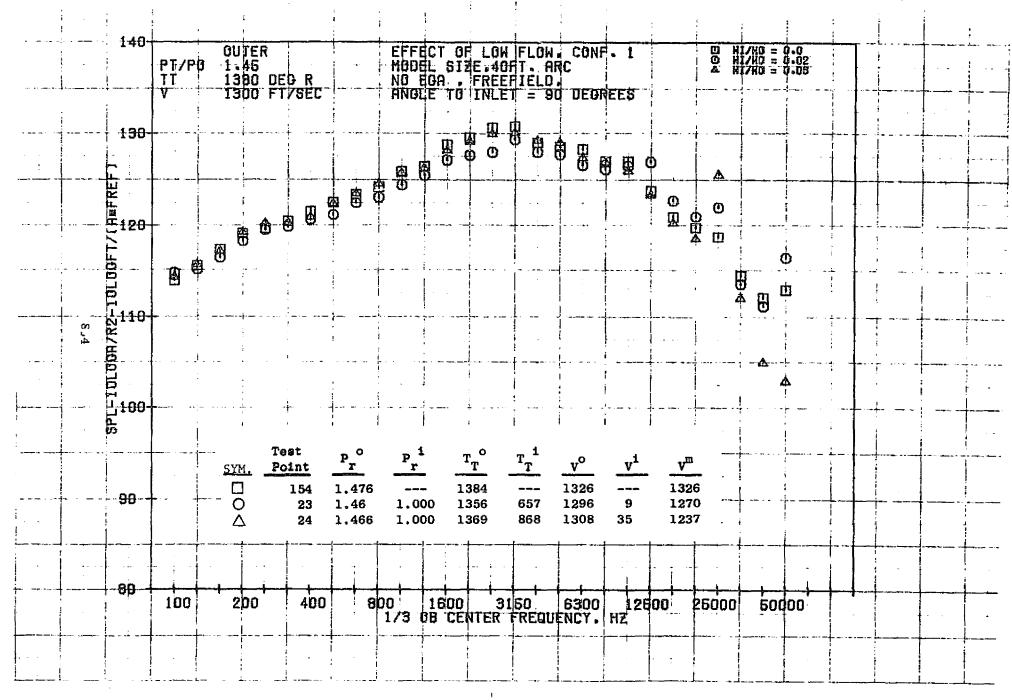
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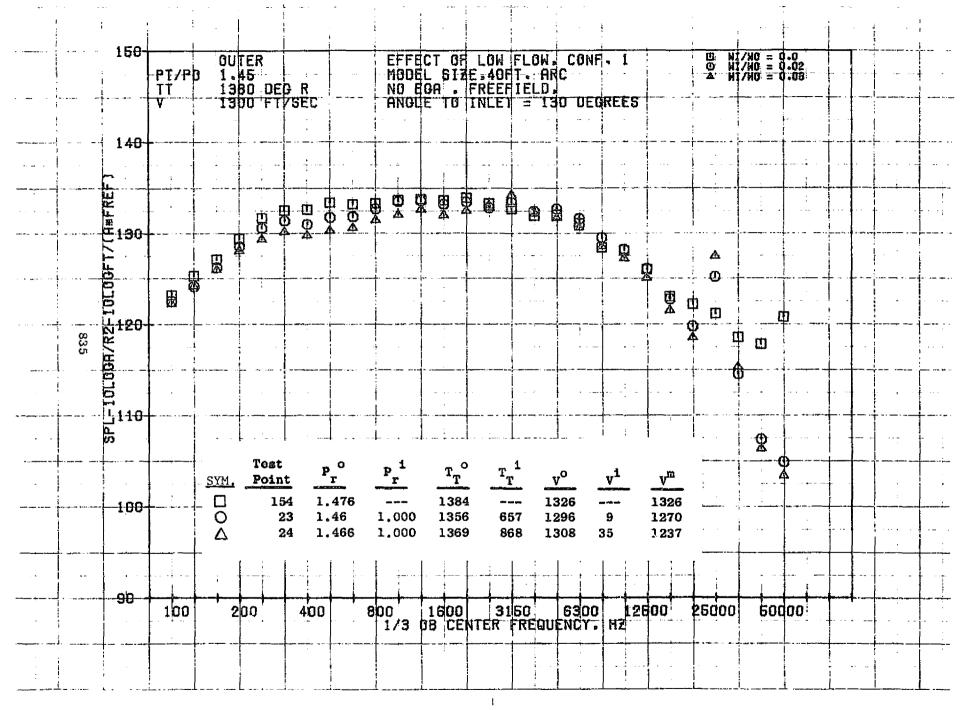
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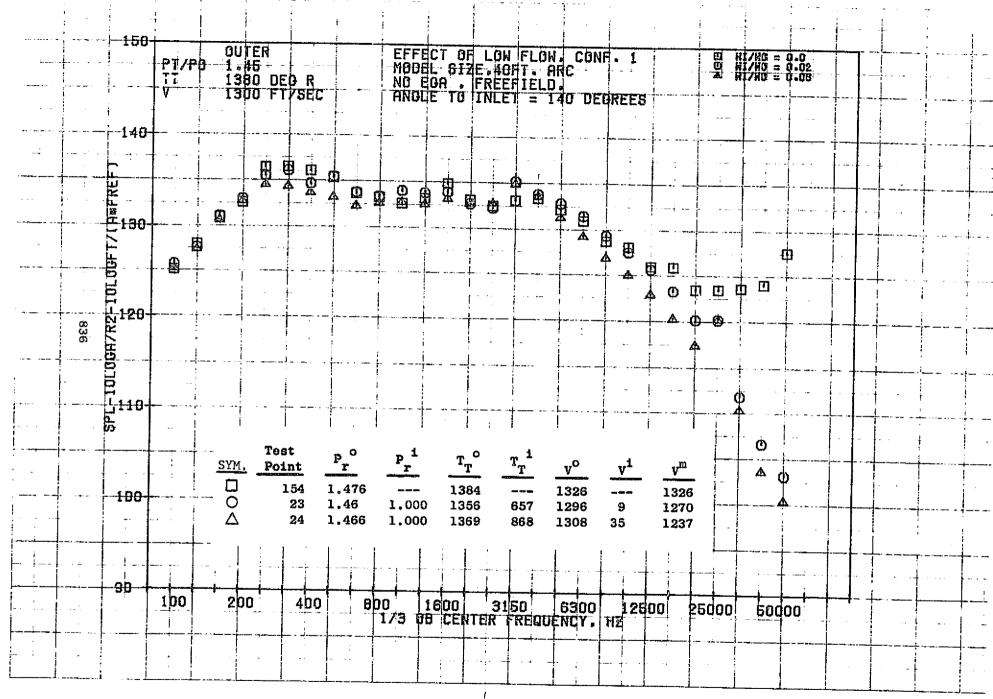


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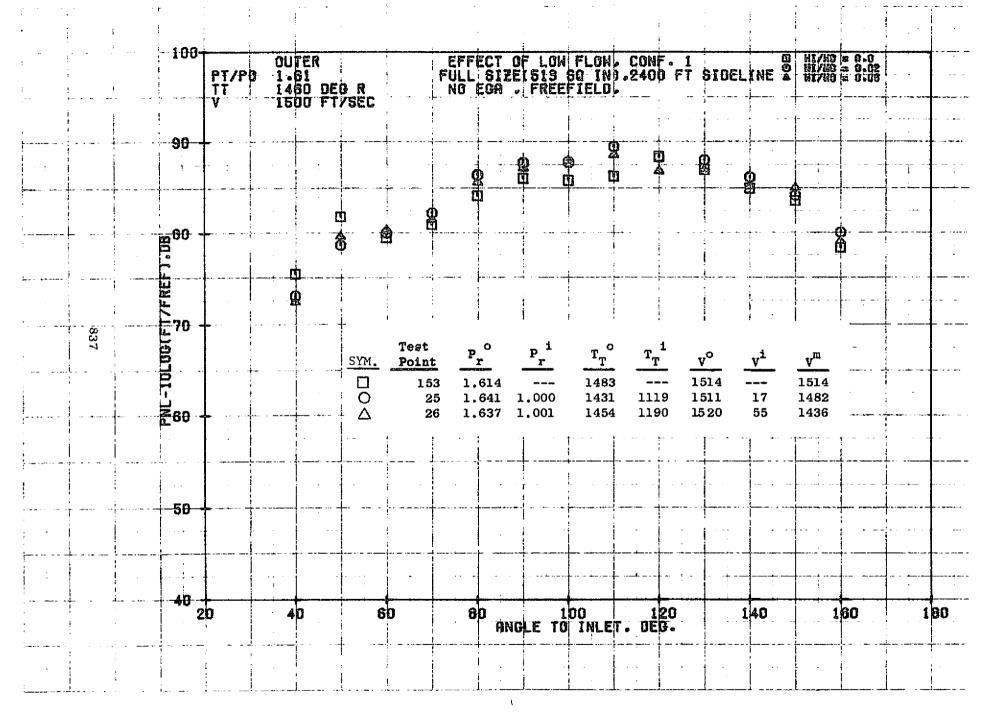




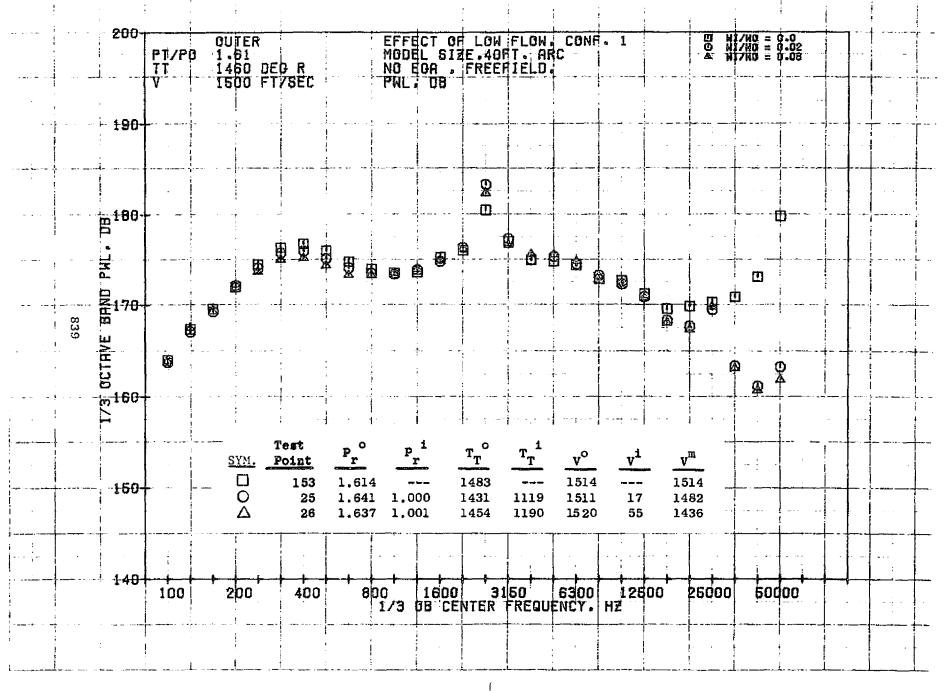
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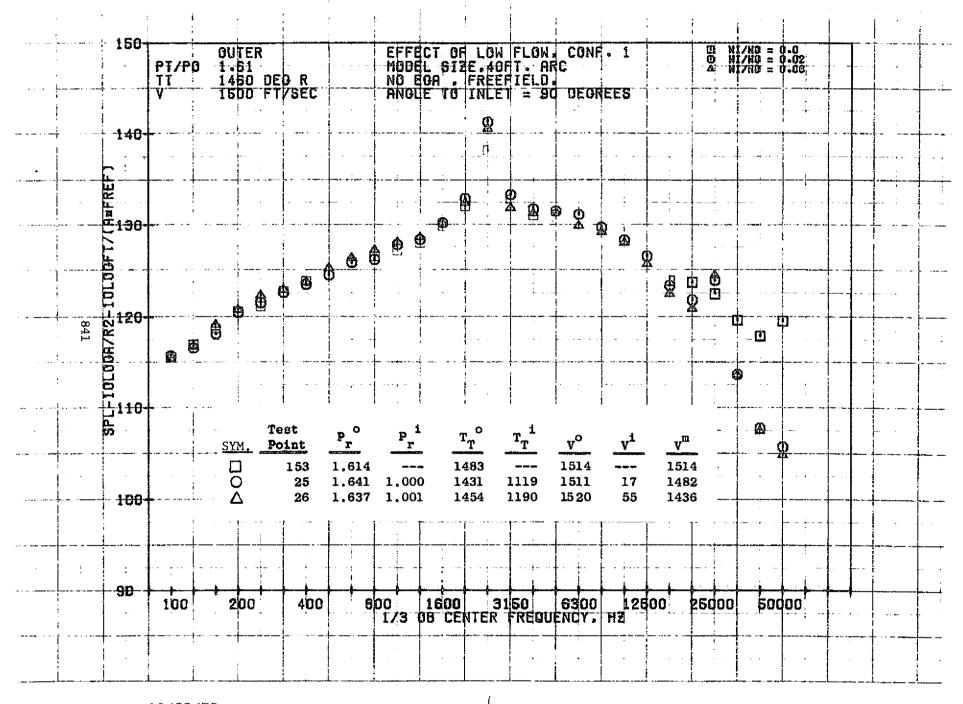
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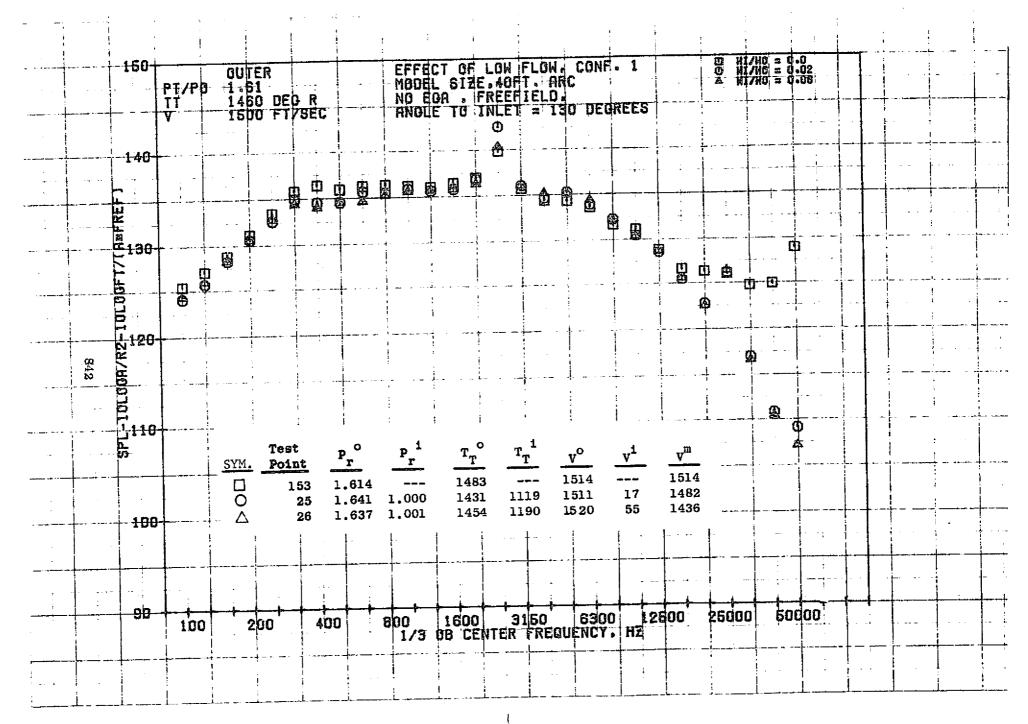


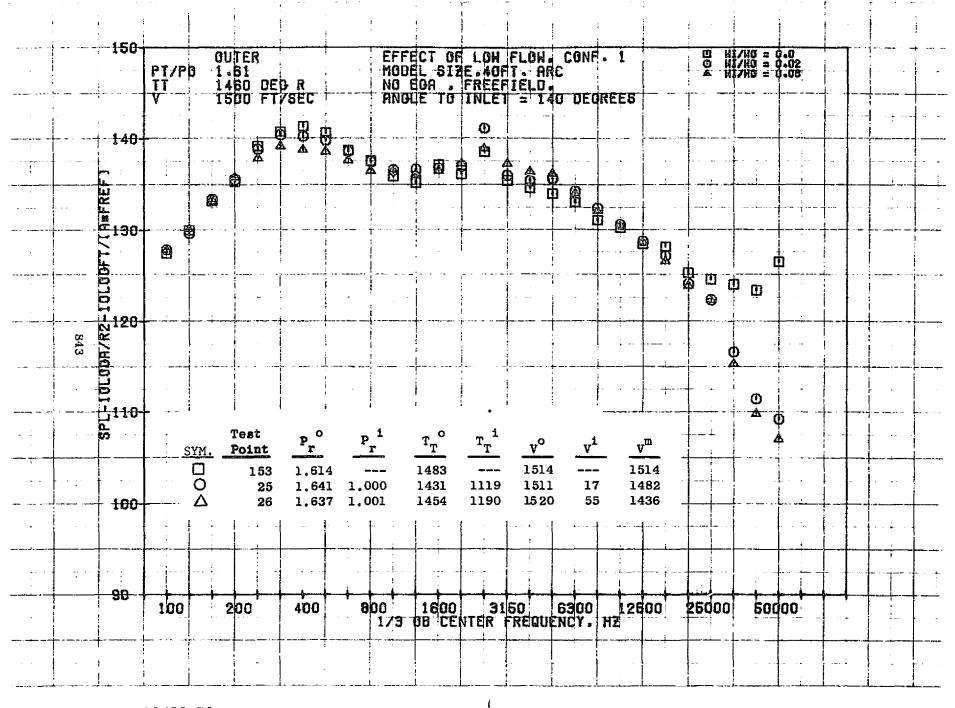
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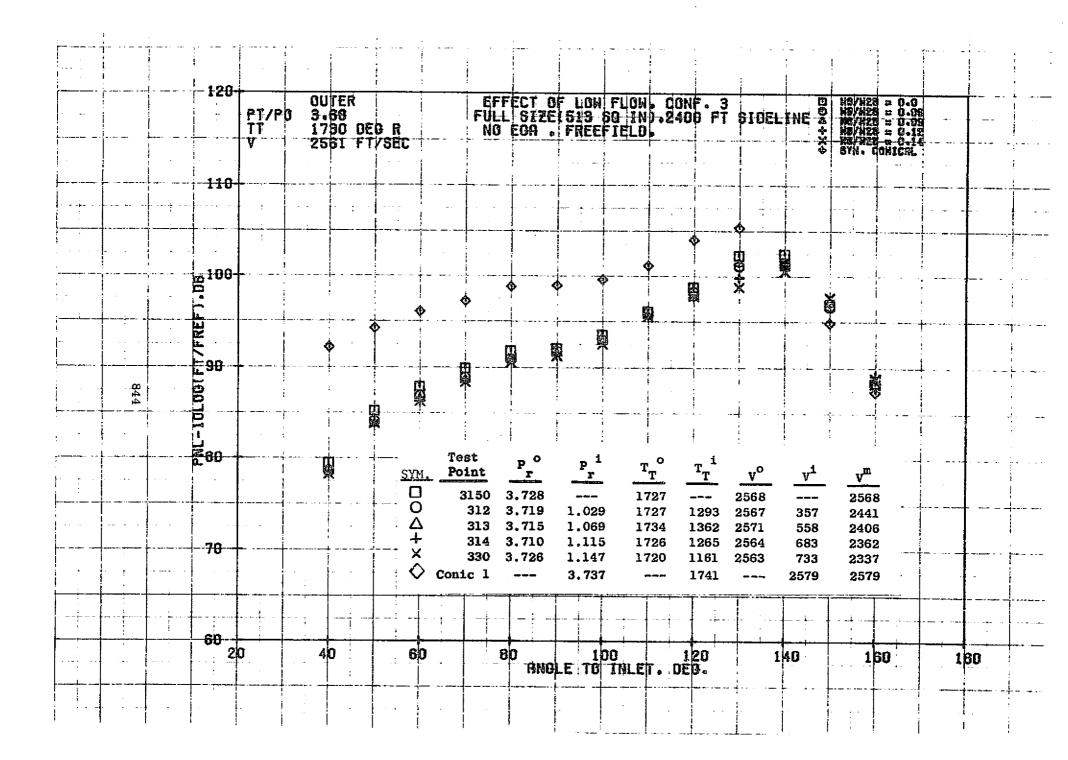
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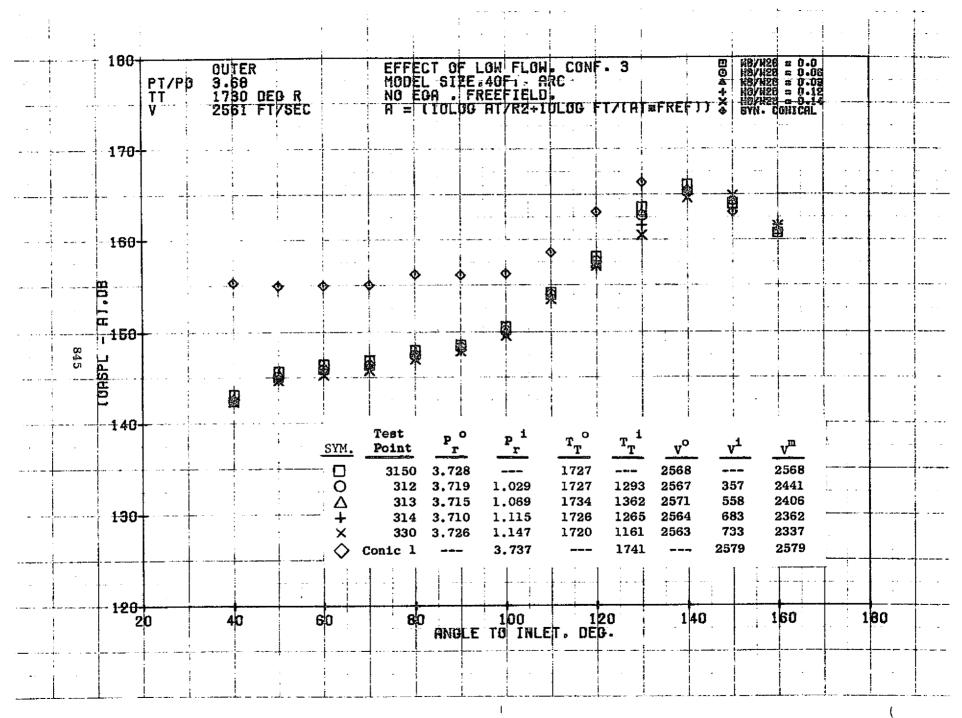


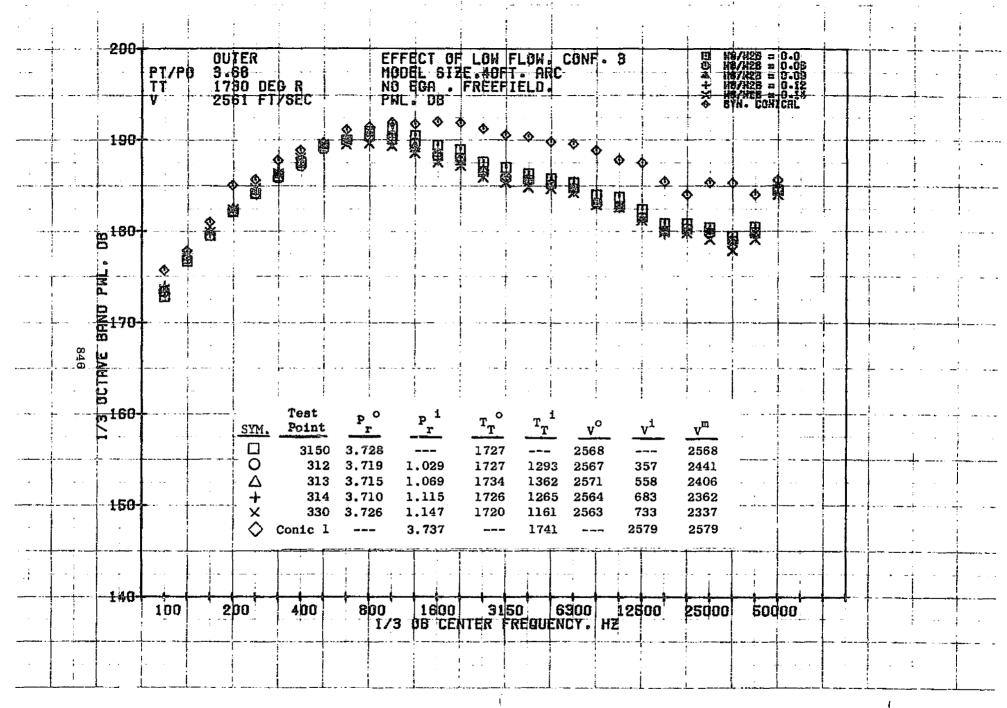


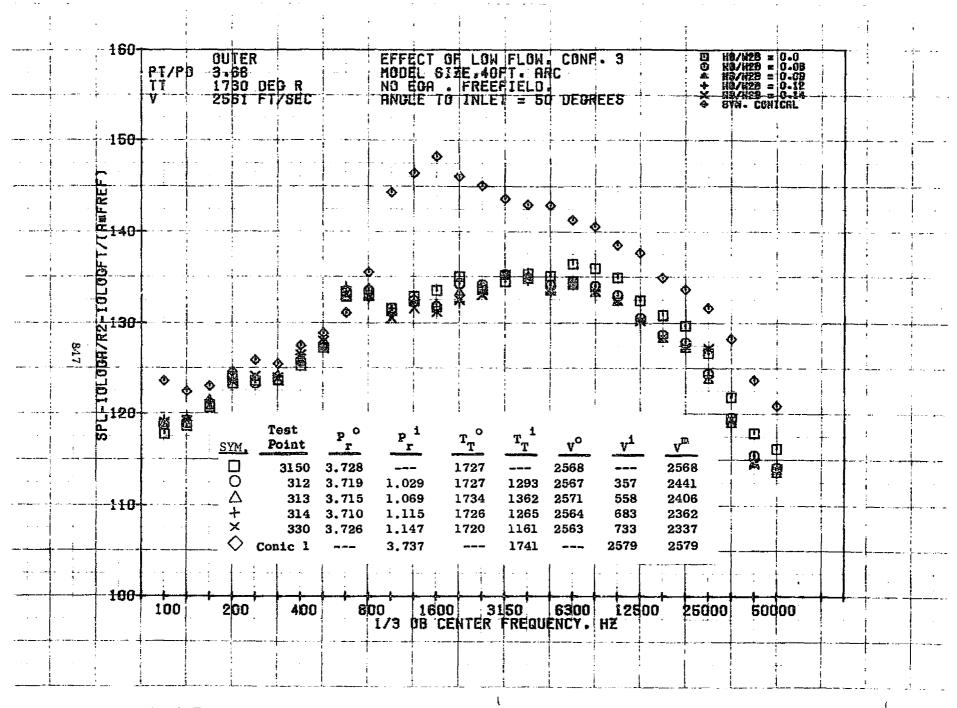
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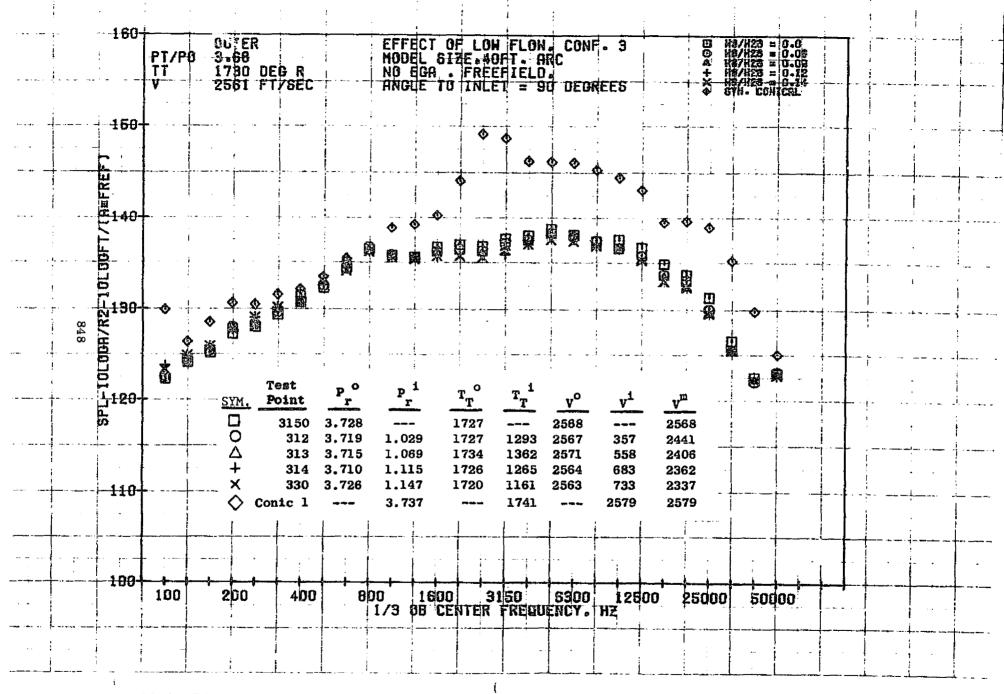


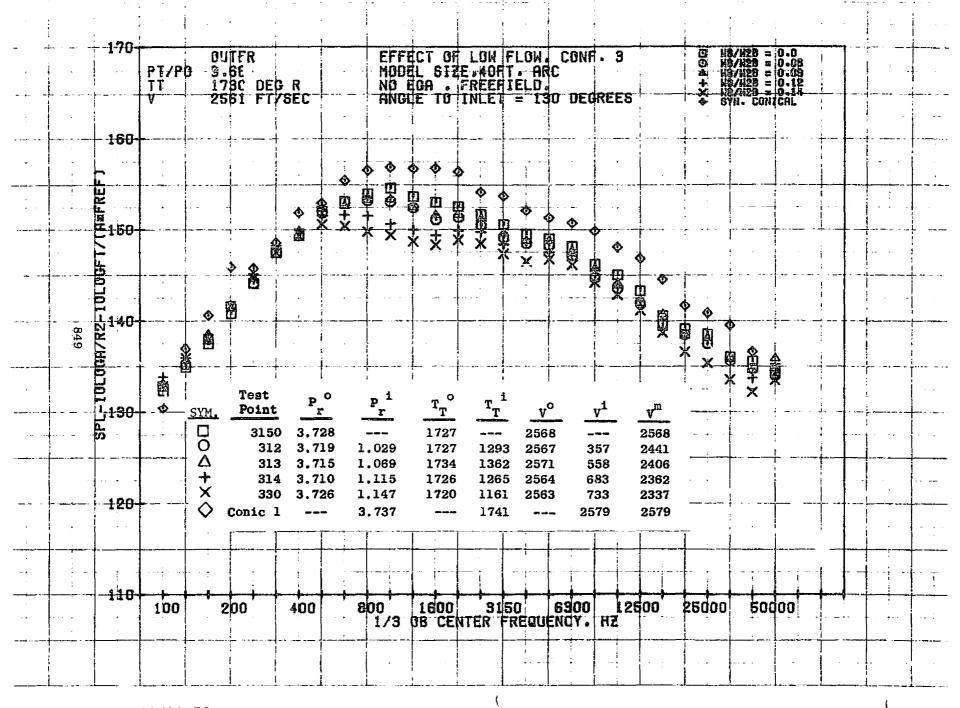
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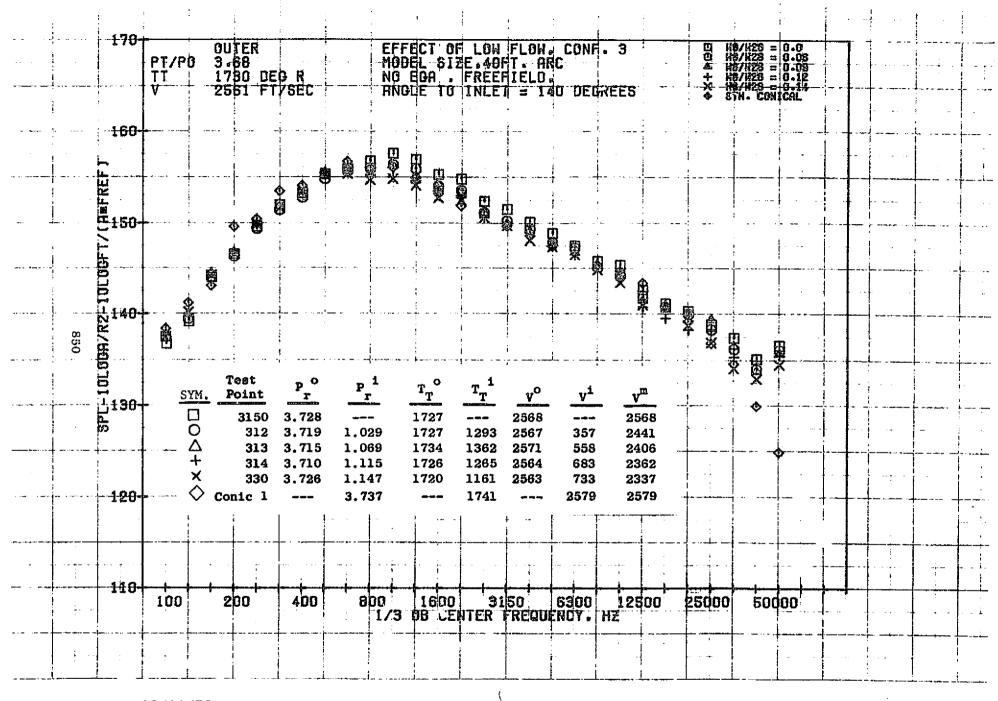








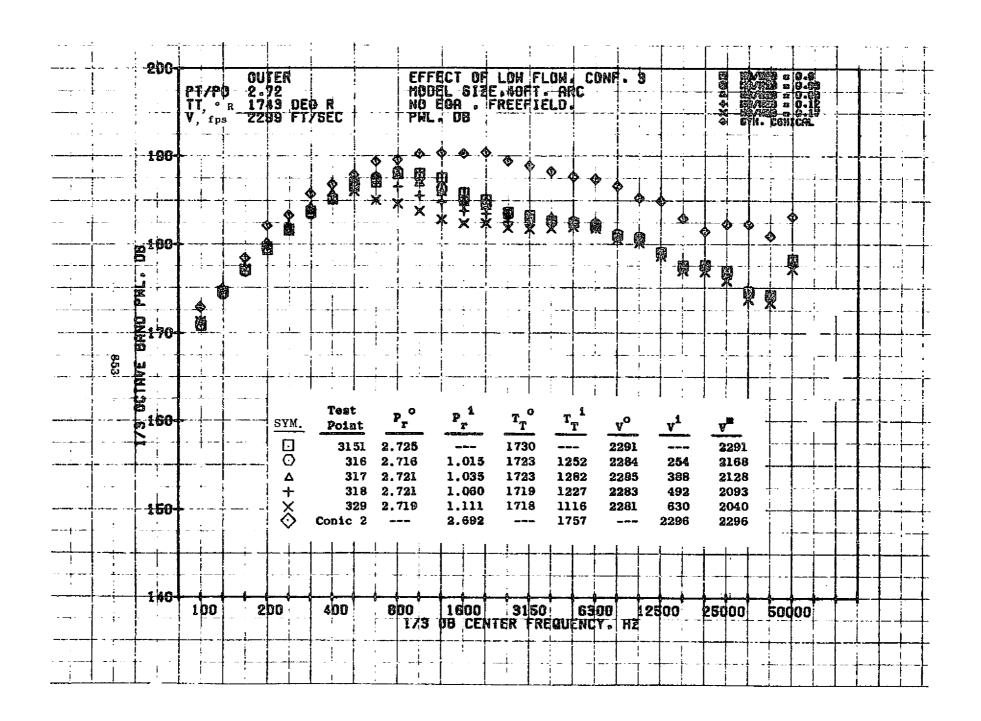
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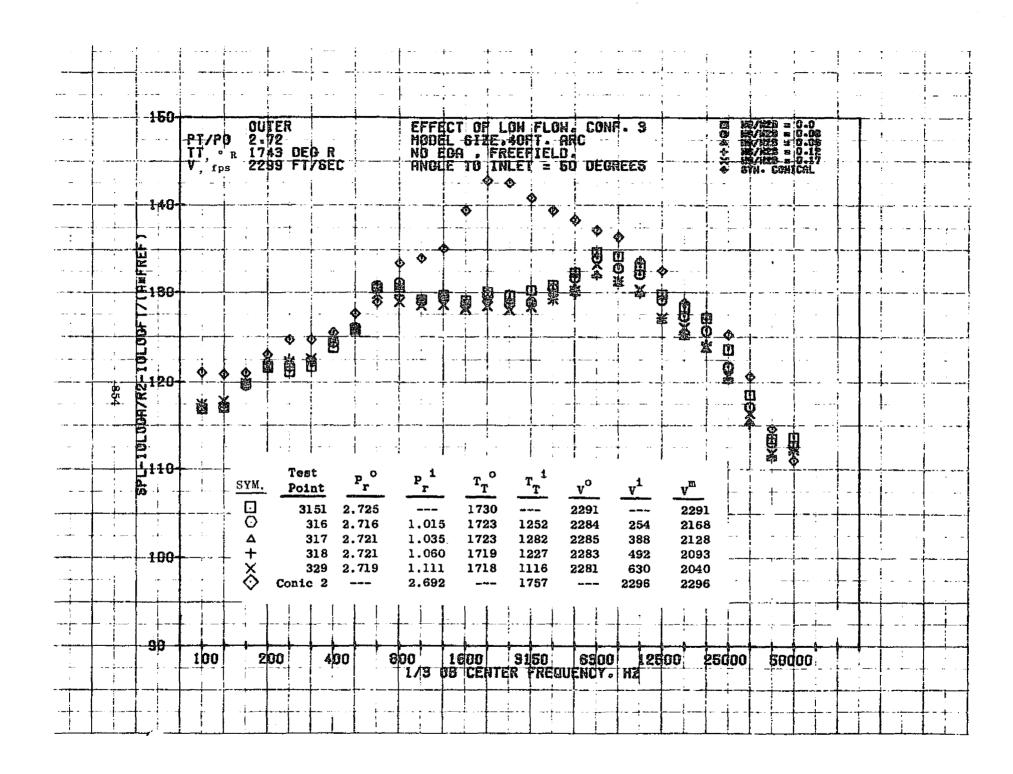


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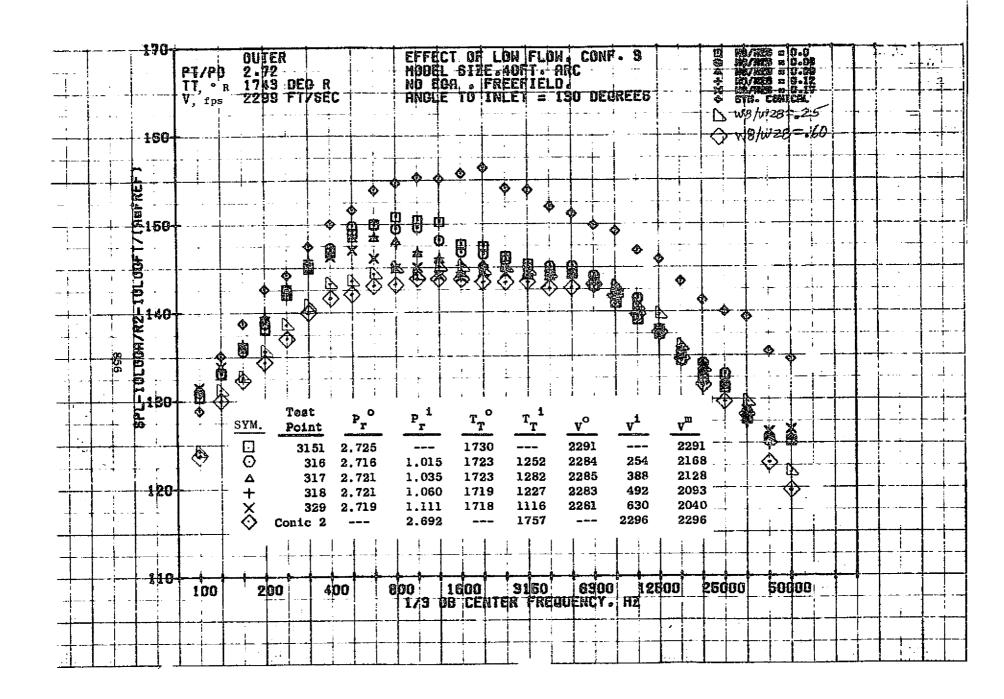


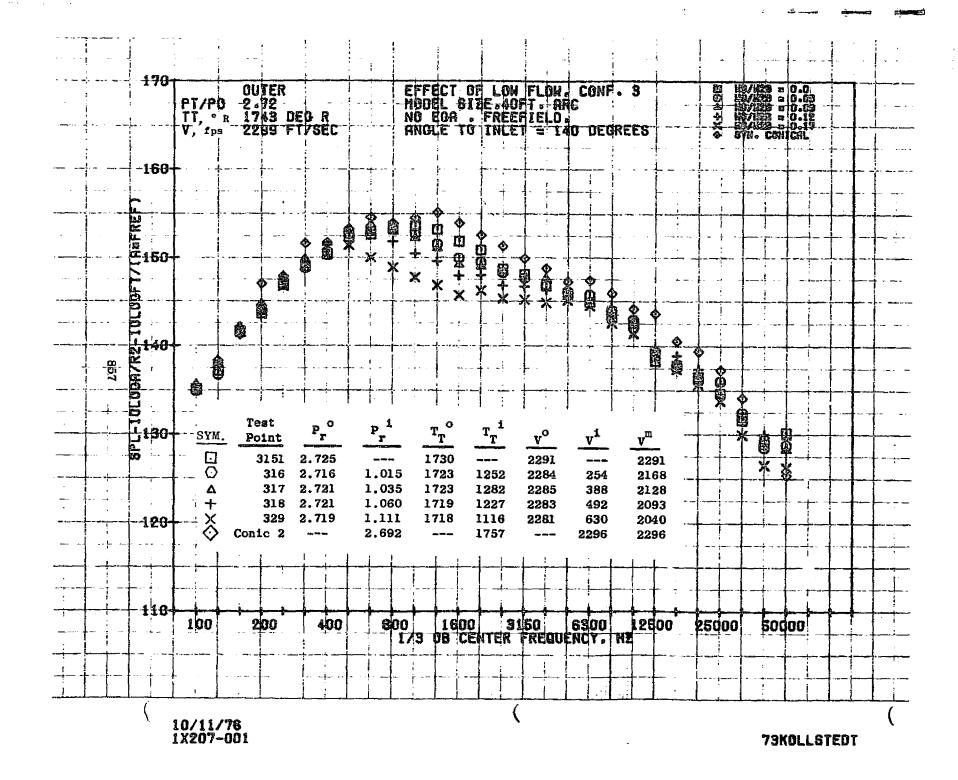


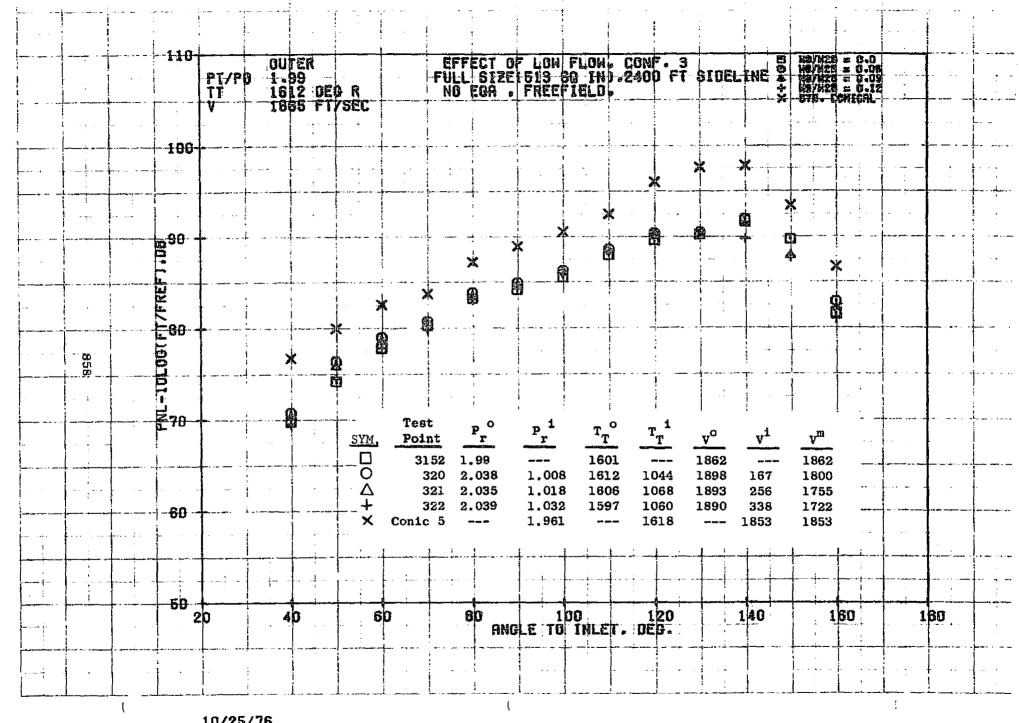
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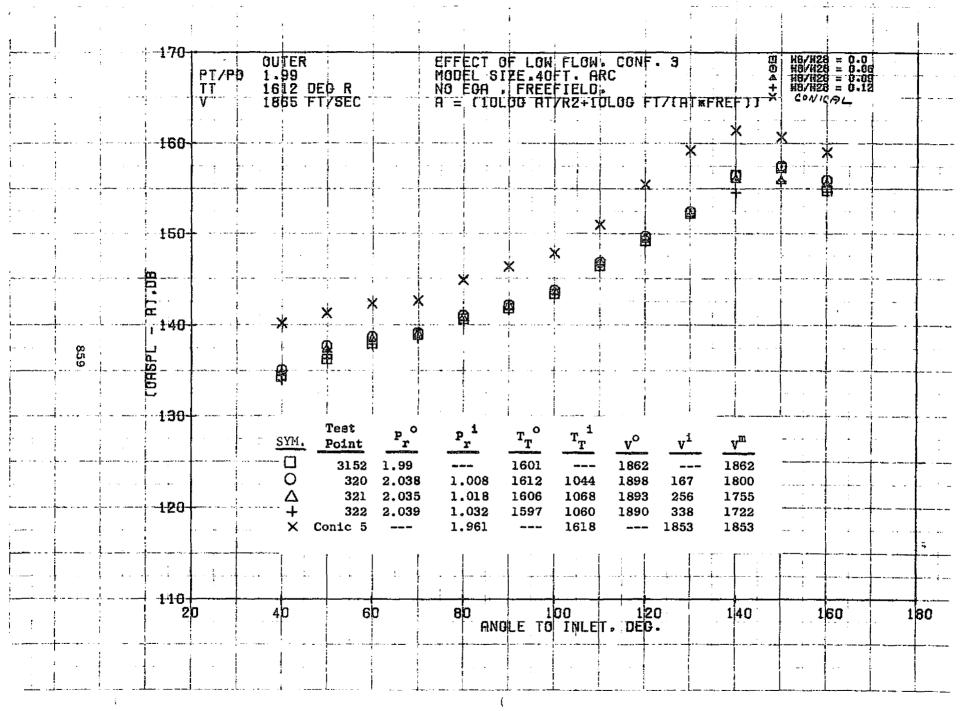


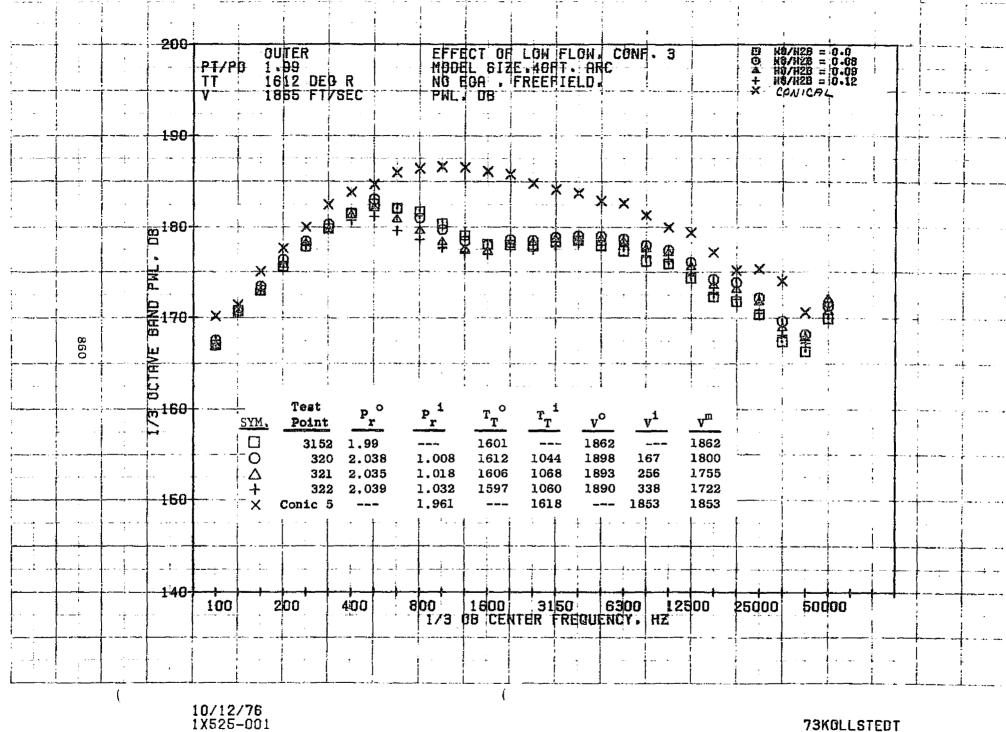


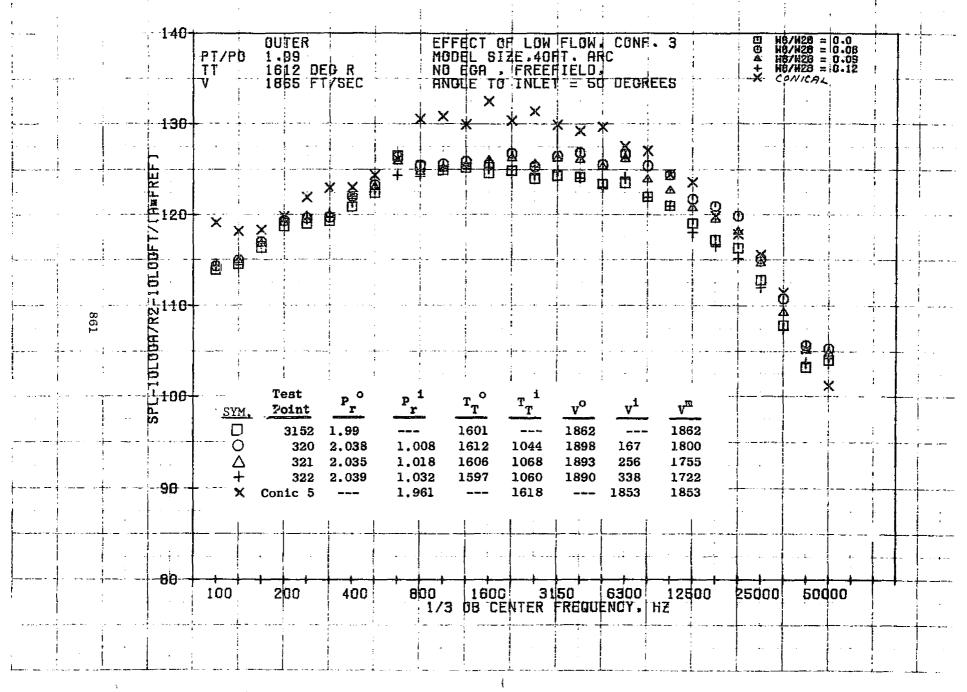


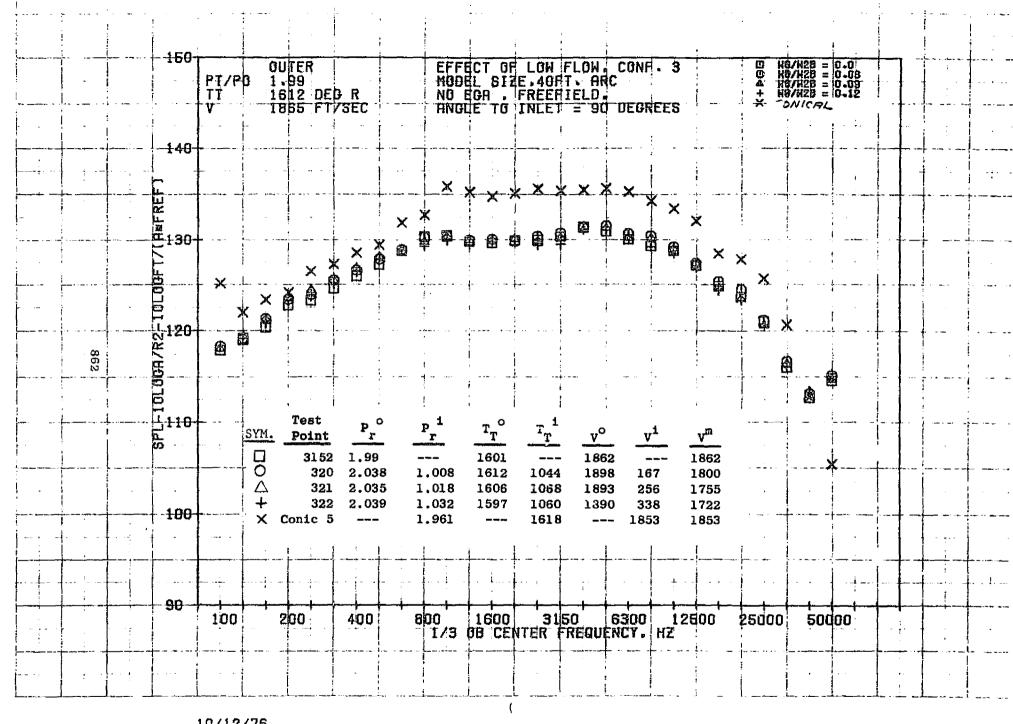
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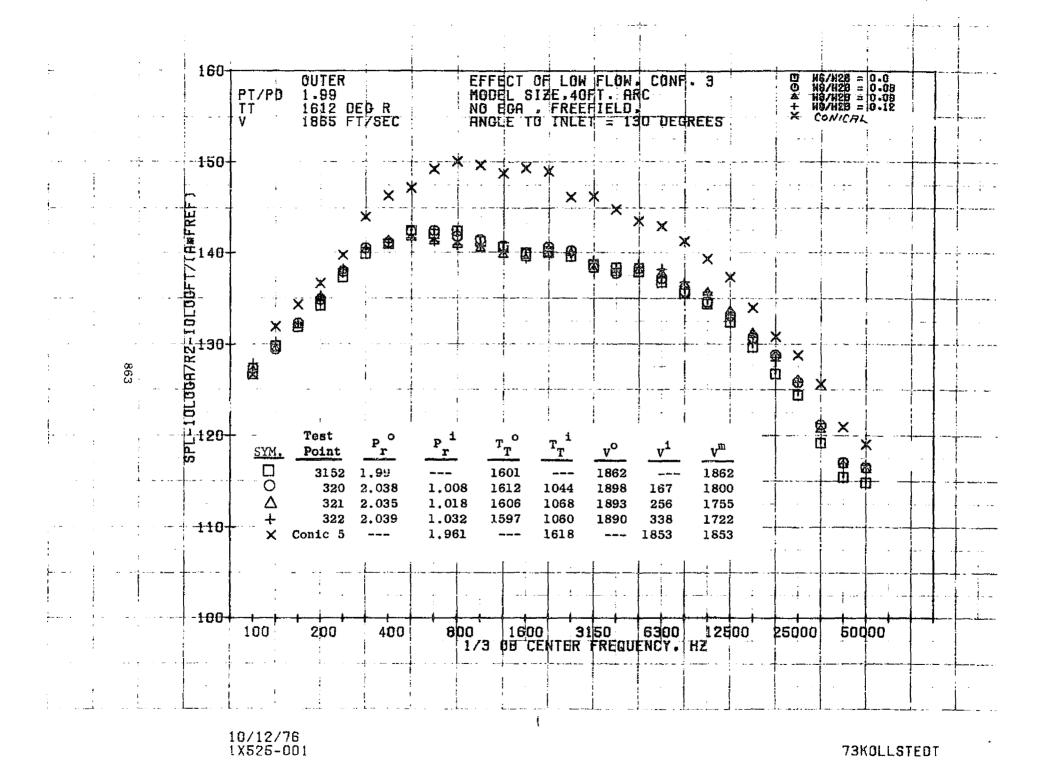


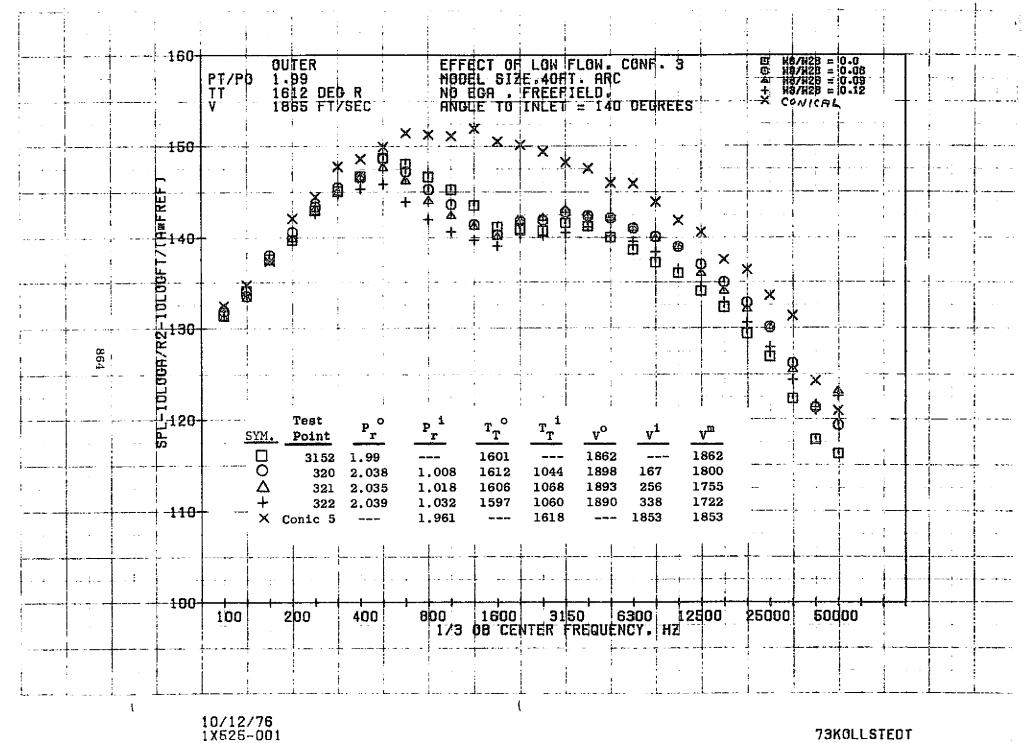


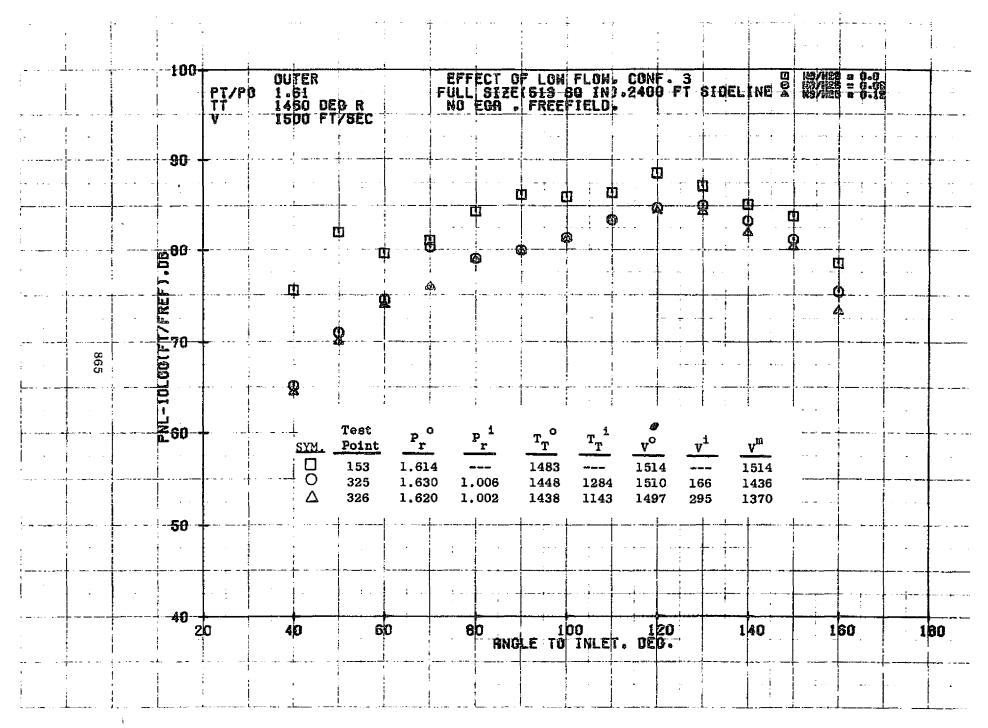


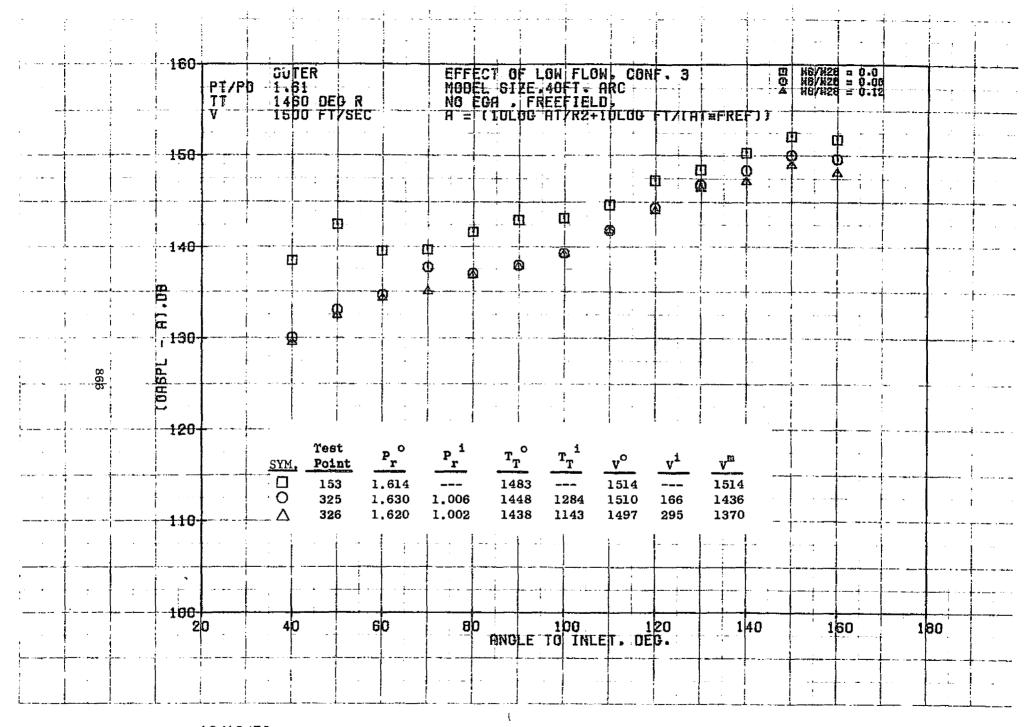
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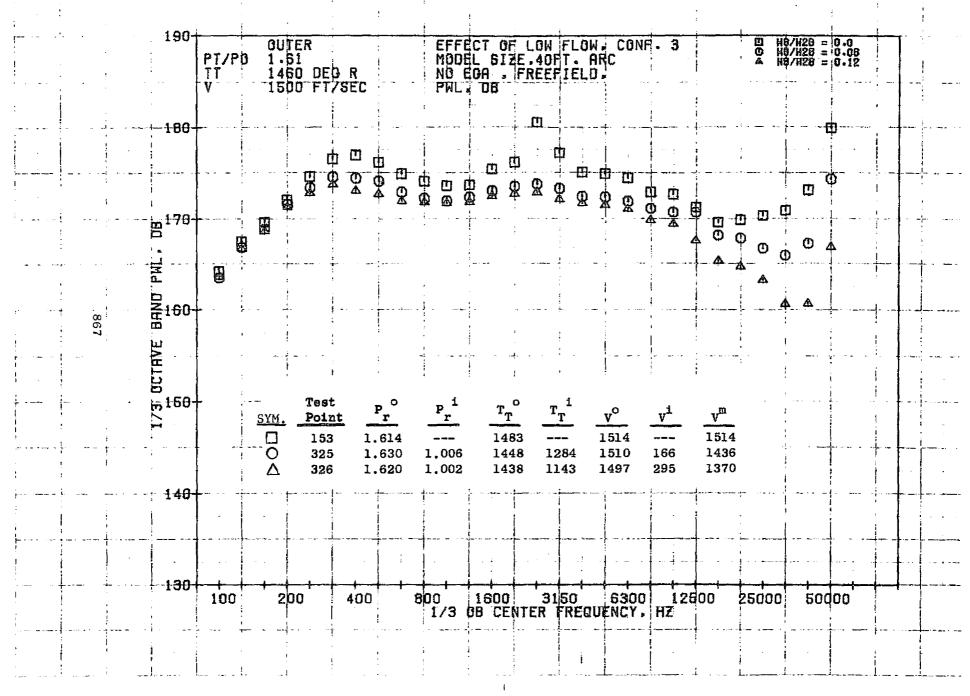
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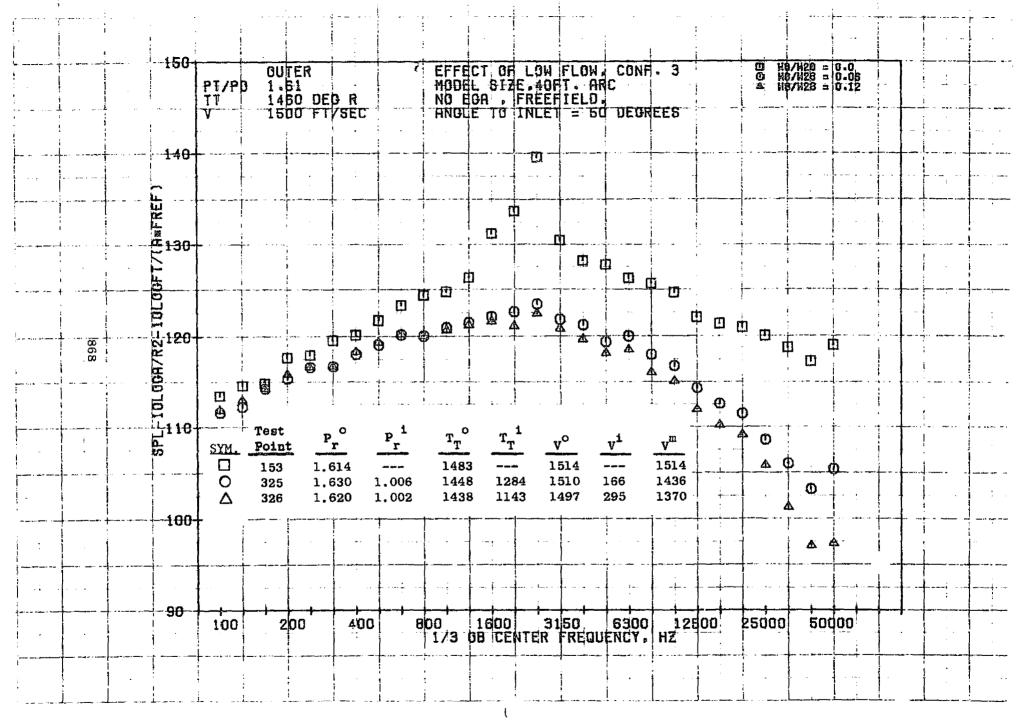






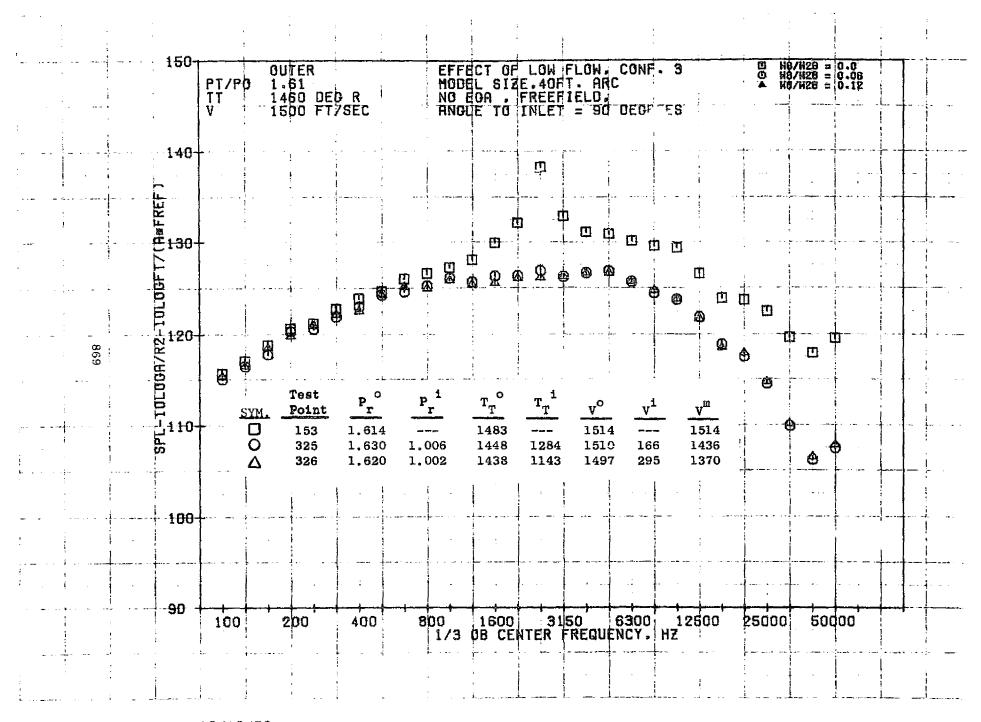


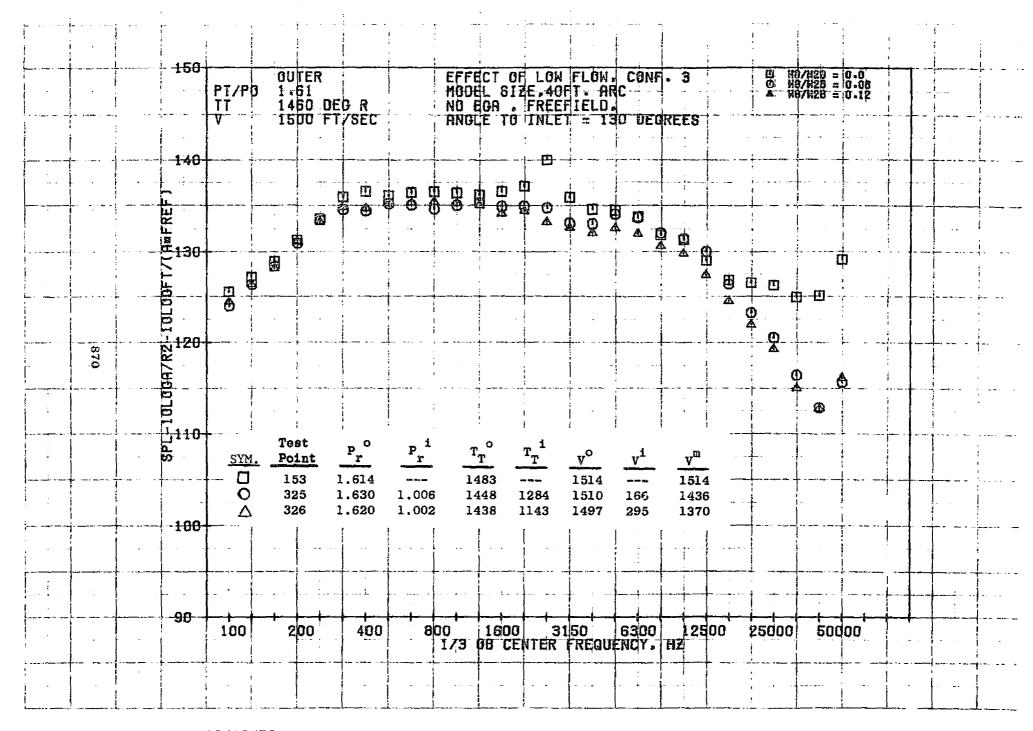


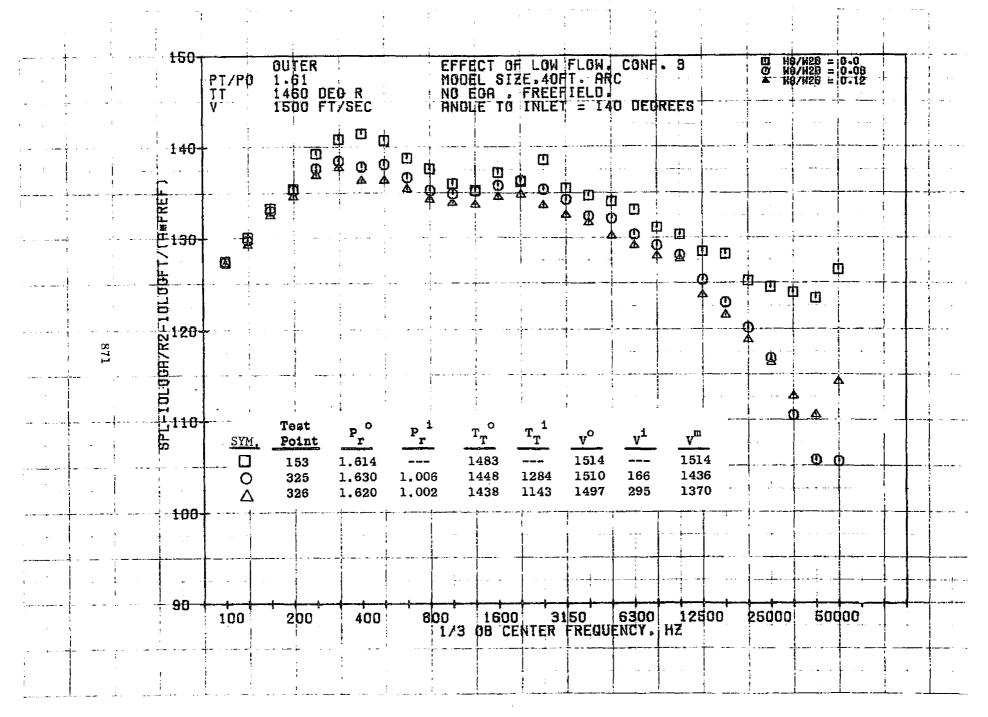


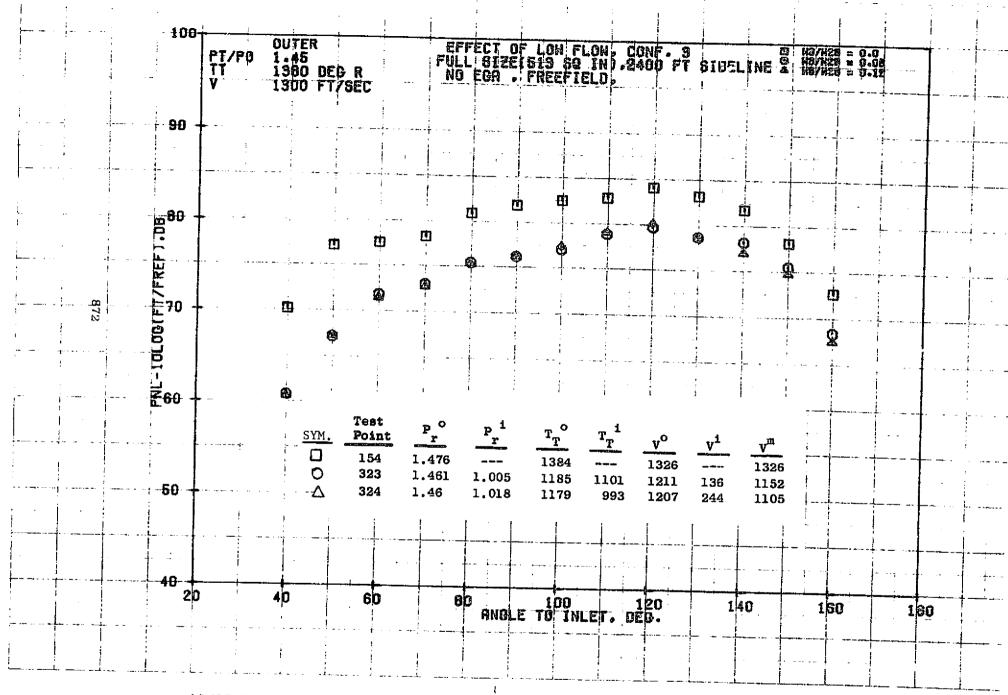
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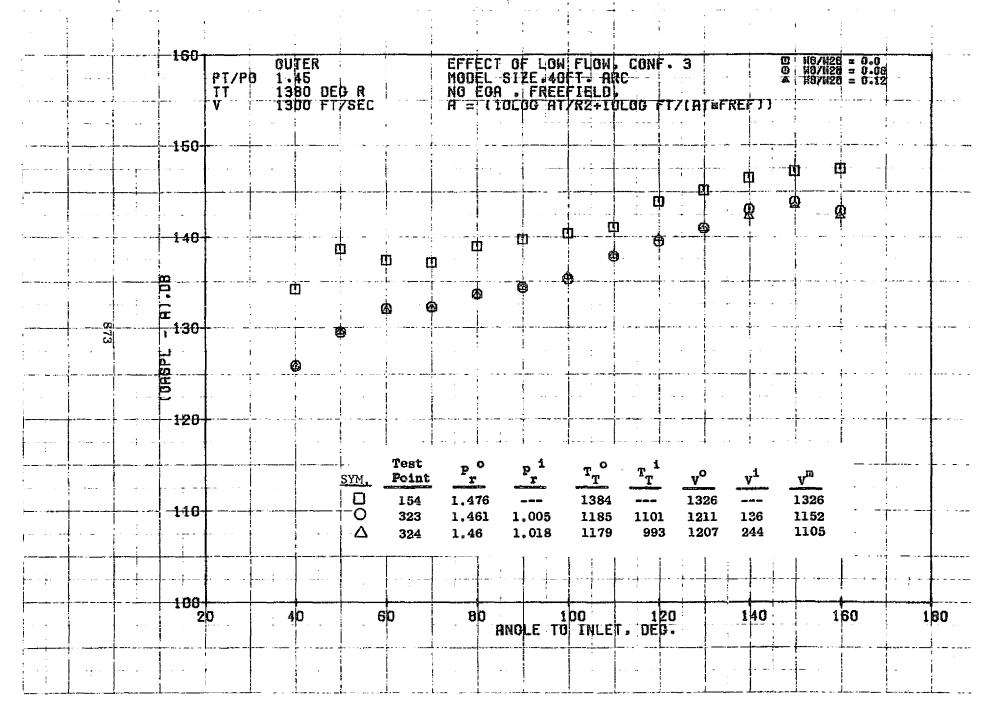
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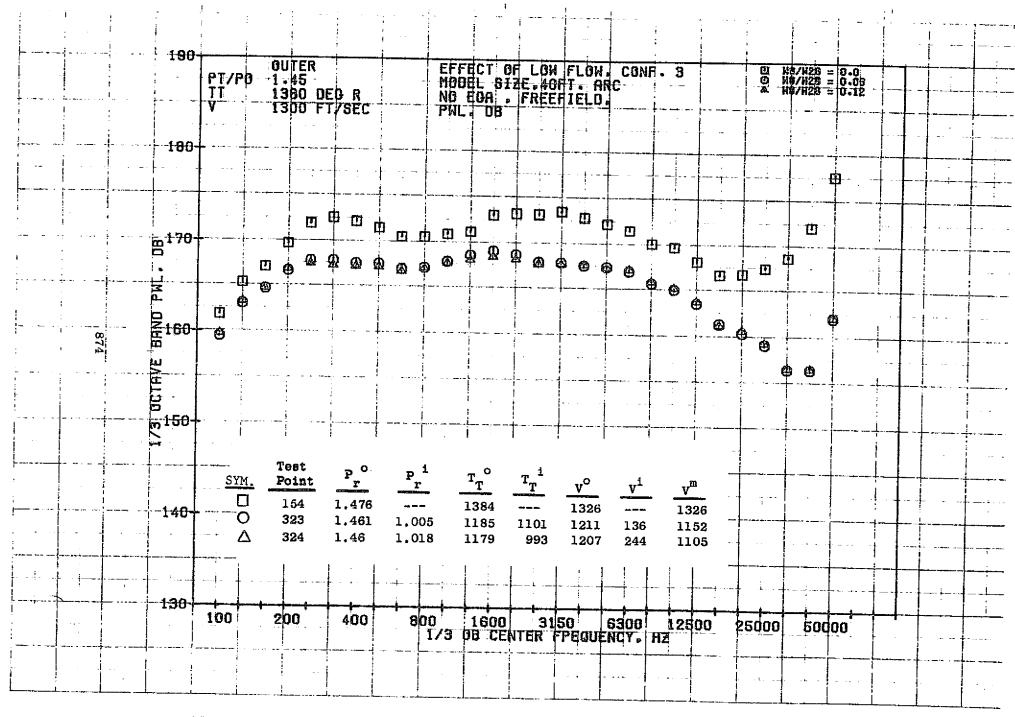




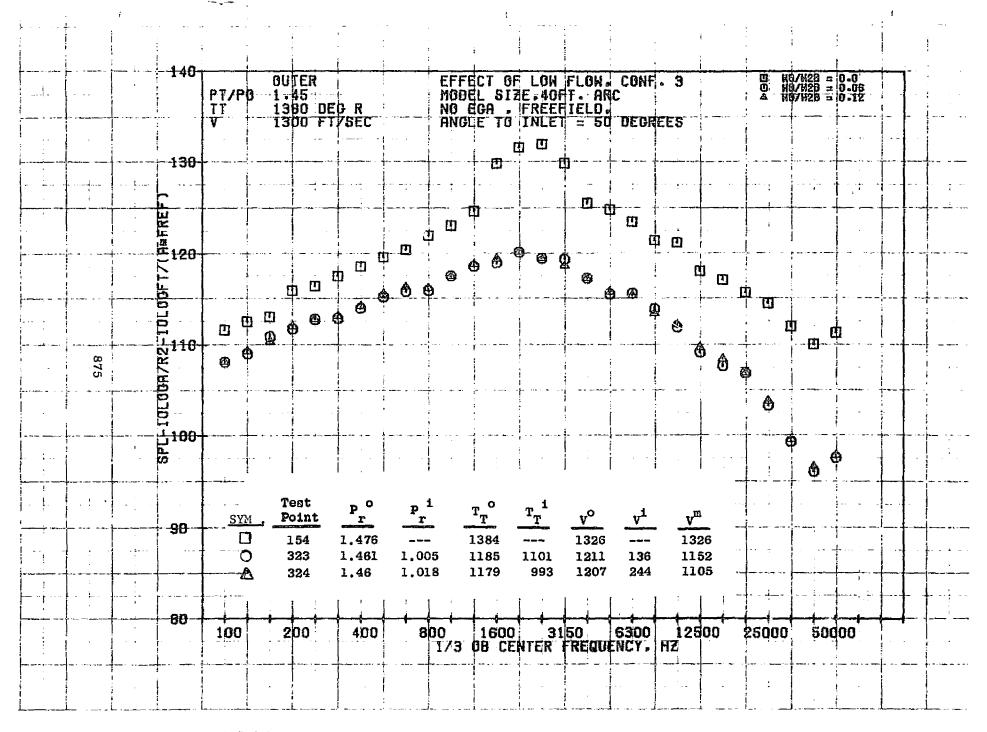


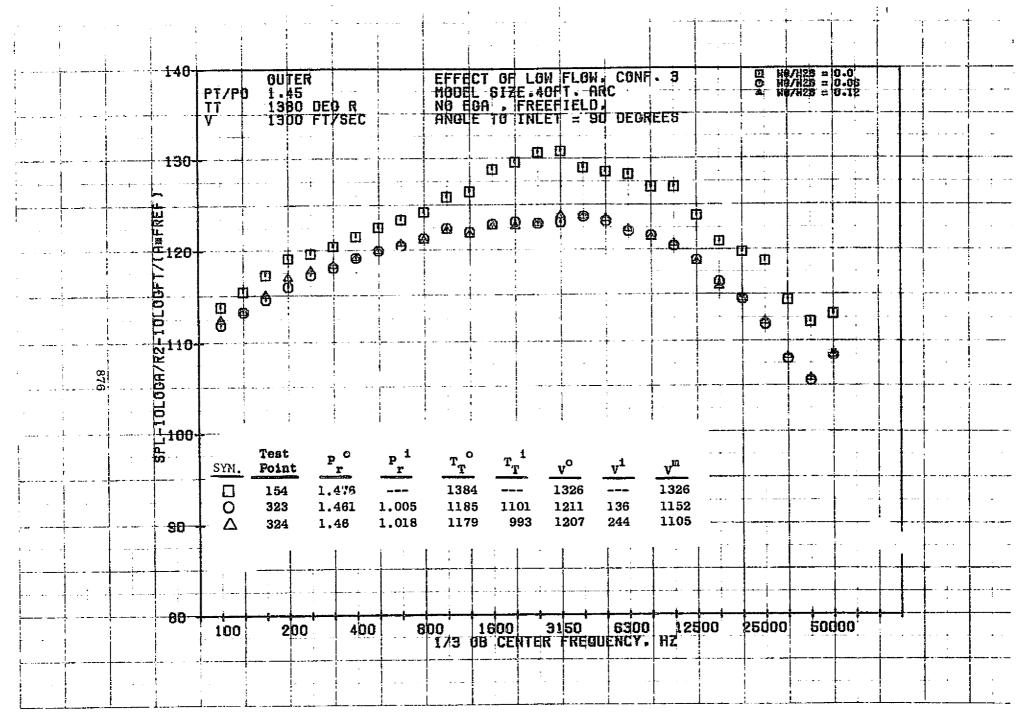


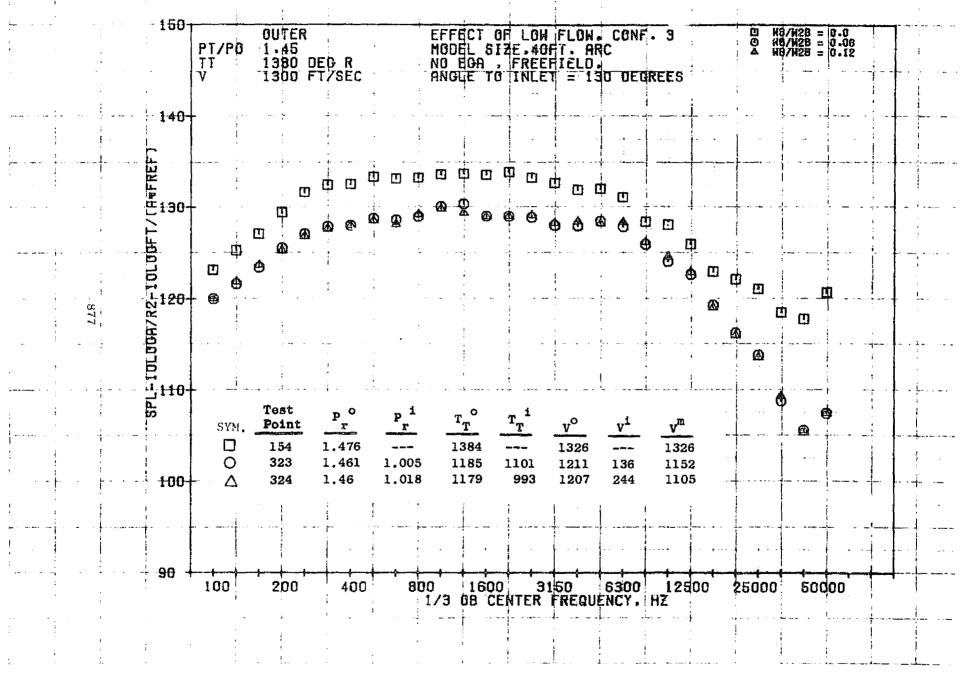


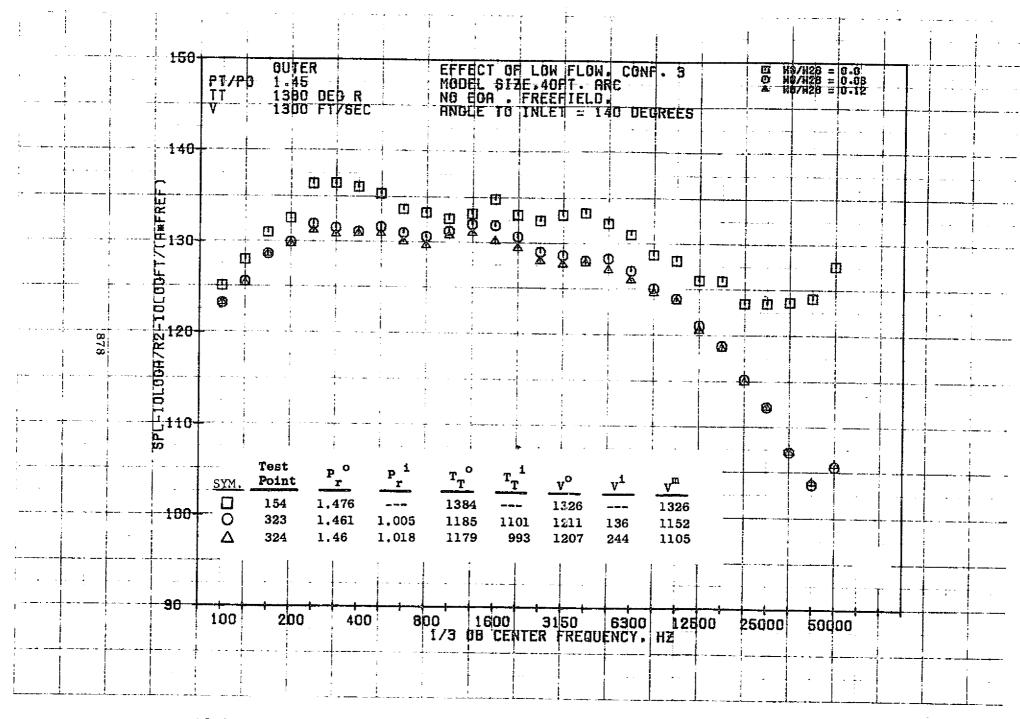


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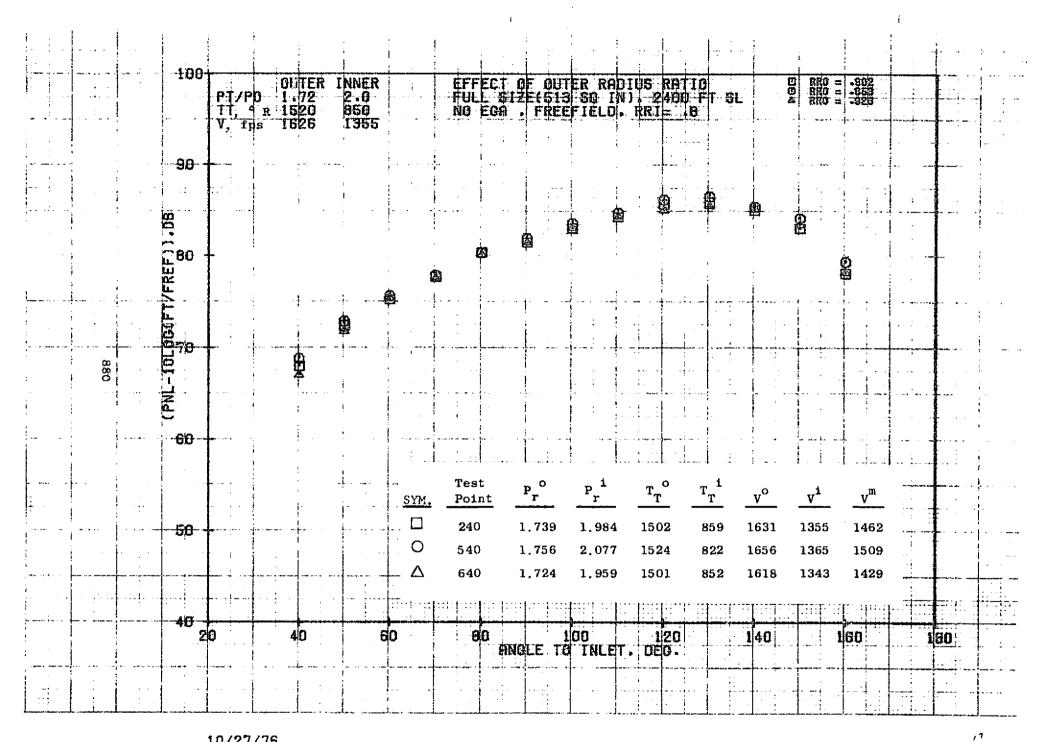


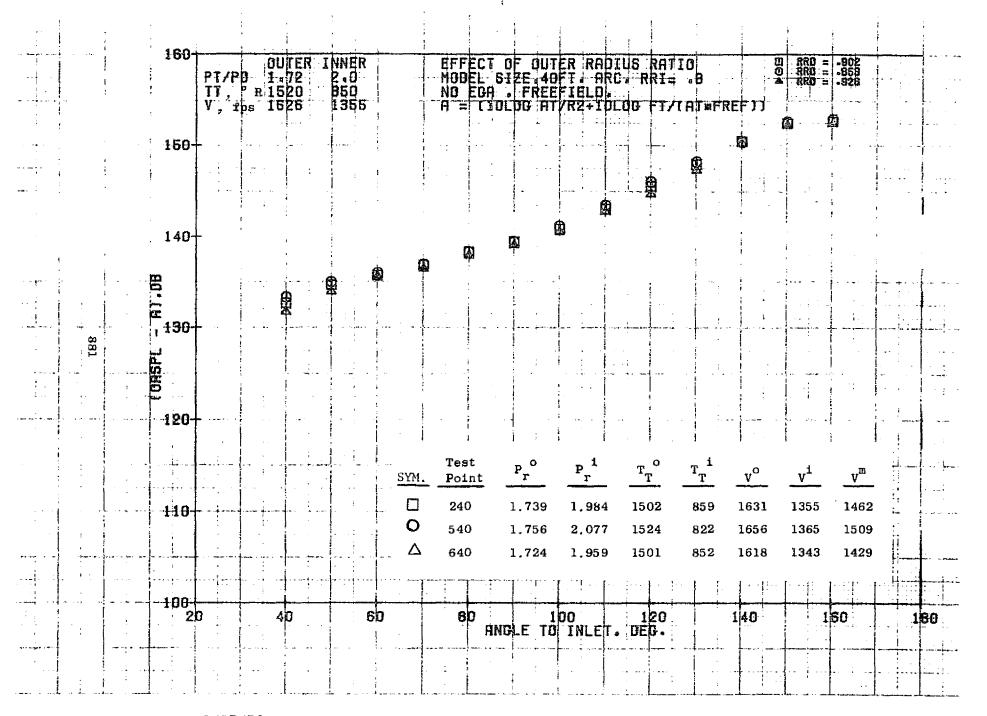
7.4 COMPARISONS OF DATA FOR IVP NOZZLES WITH HIGH AMOUNTS OF INNER FLOW

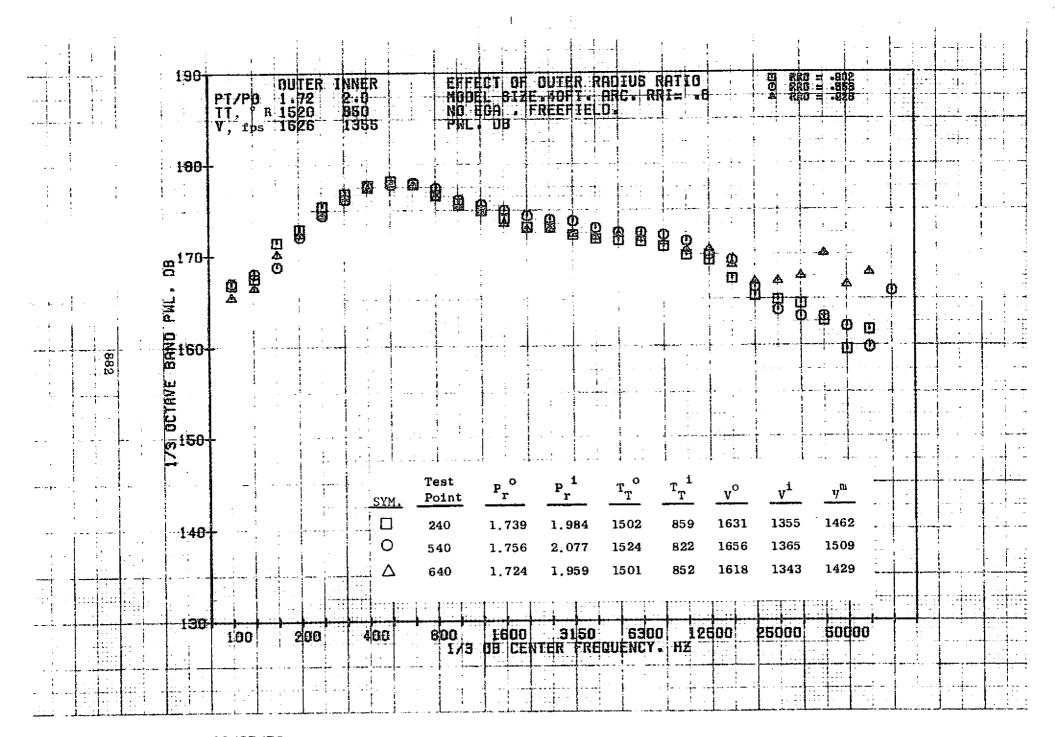
The purpose of this test series was to examine the noise suppression characteristics of coannular nozzle configurations with high inner flows. Data presentations are described in the following sections.

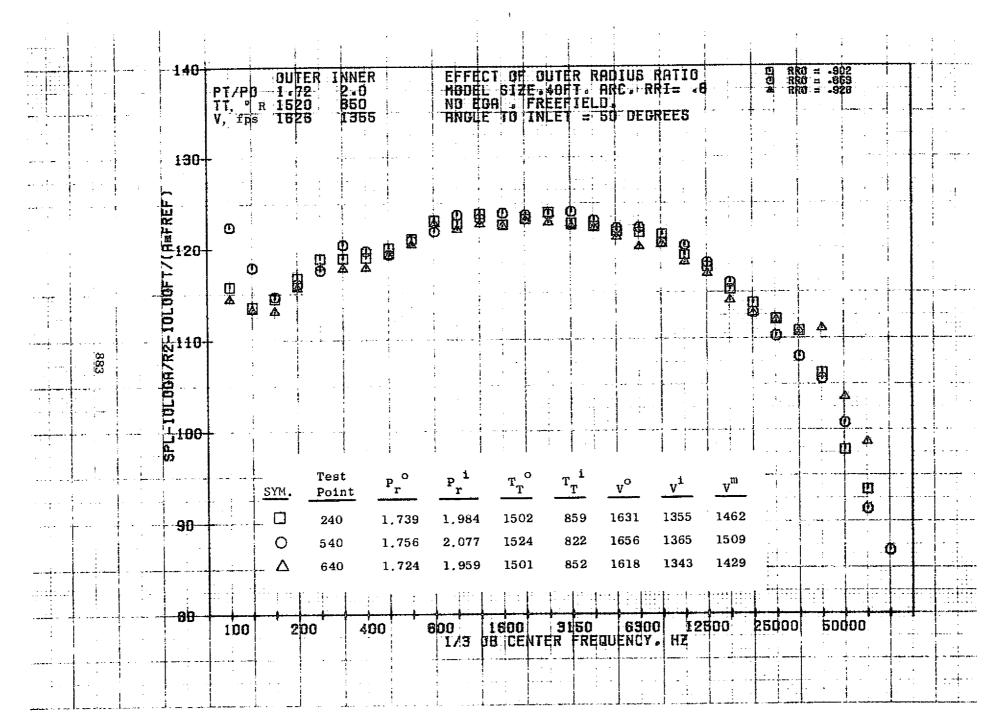
7.4.1 Effect of Outer Radius Ratio

In this section, the test results from Configurations 2, 5, and 6 are compared. All three configurations have the same inner radius ratio (0.8) and plug geometry, but the outer radius ratio varies from 0.853 to 0.926.

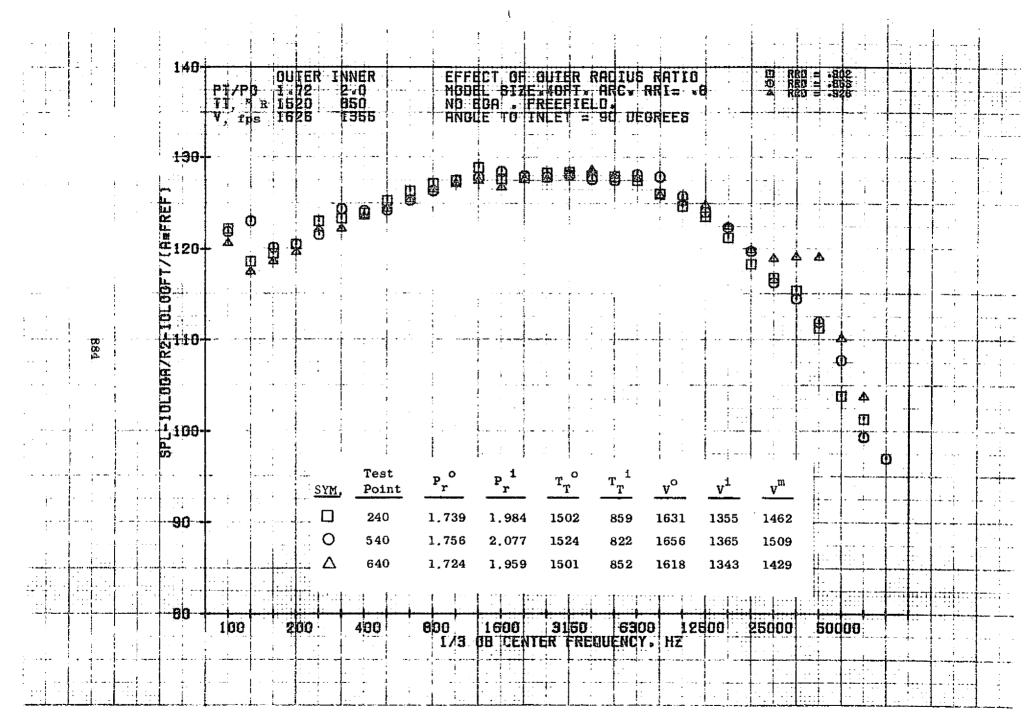


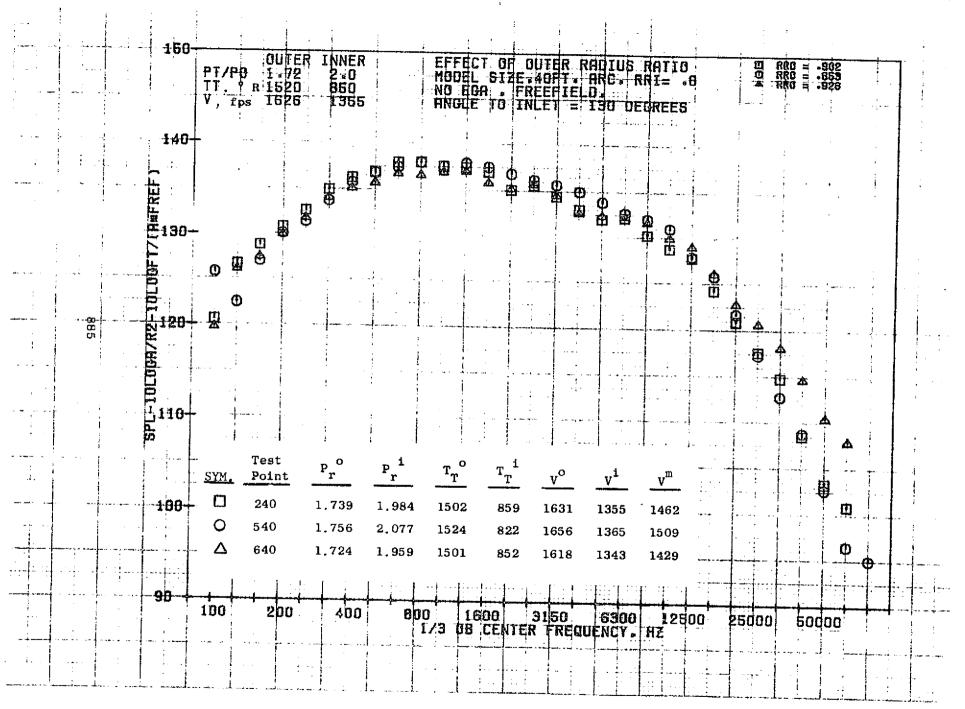


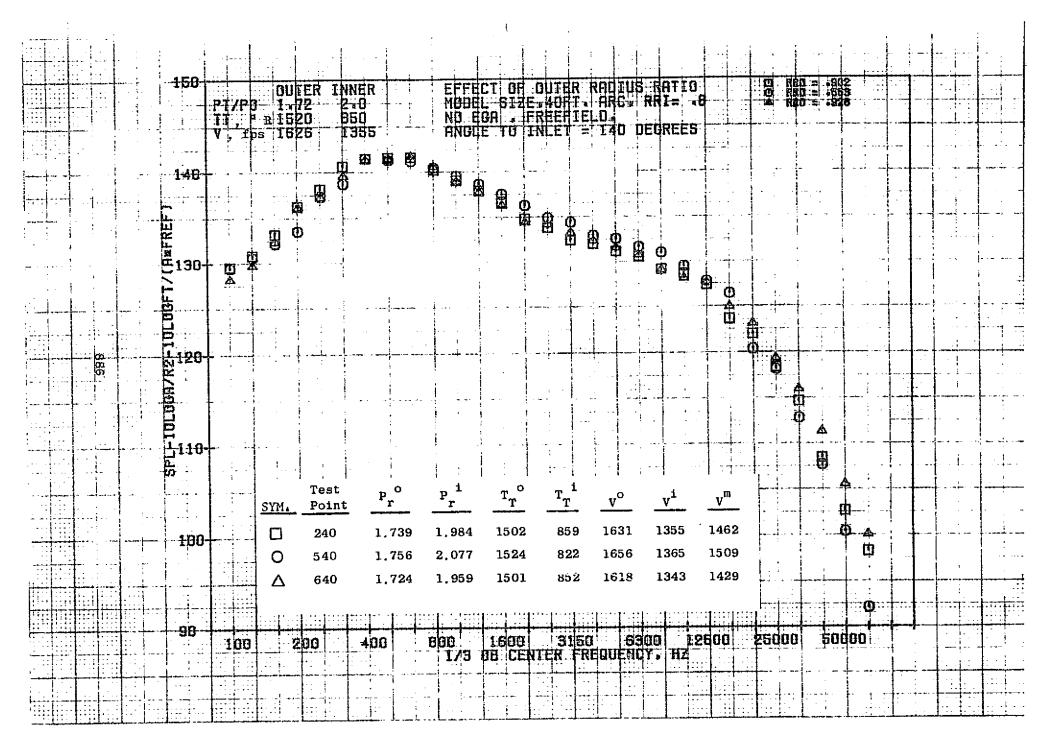




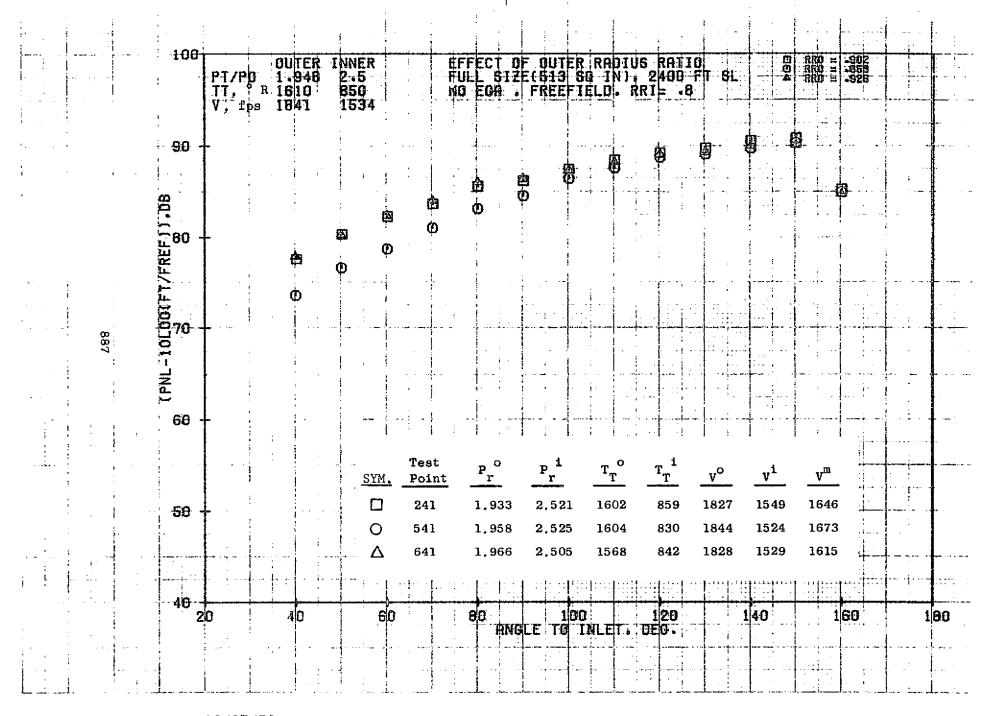
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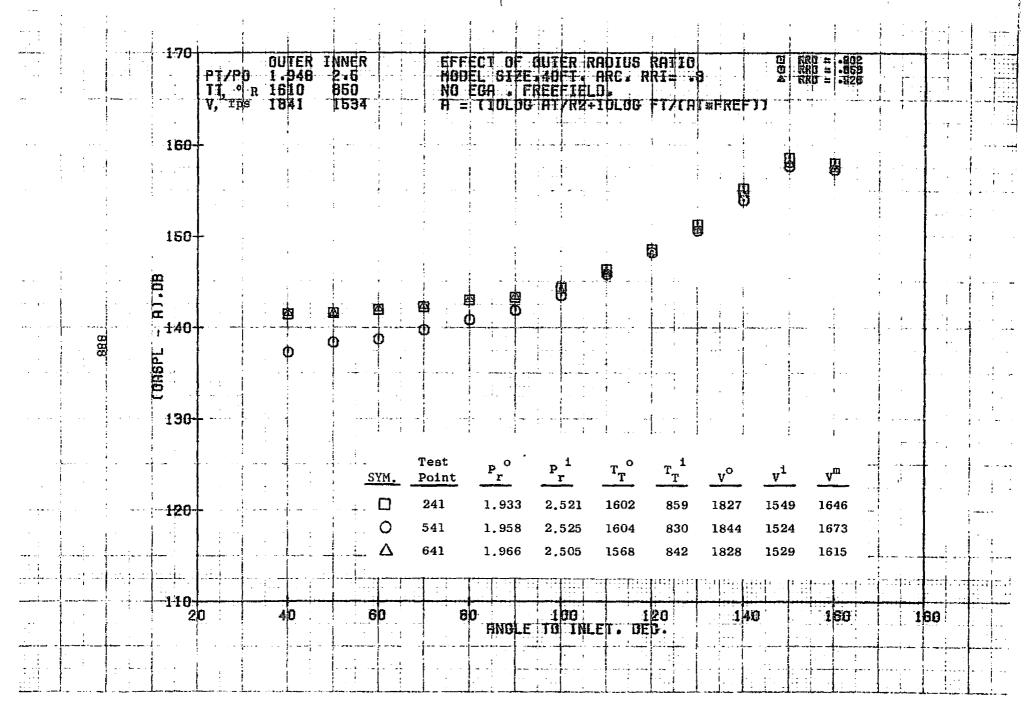


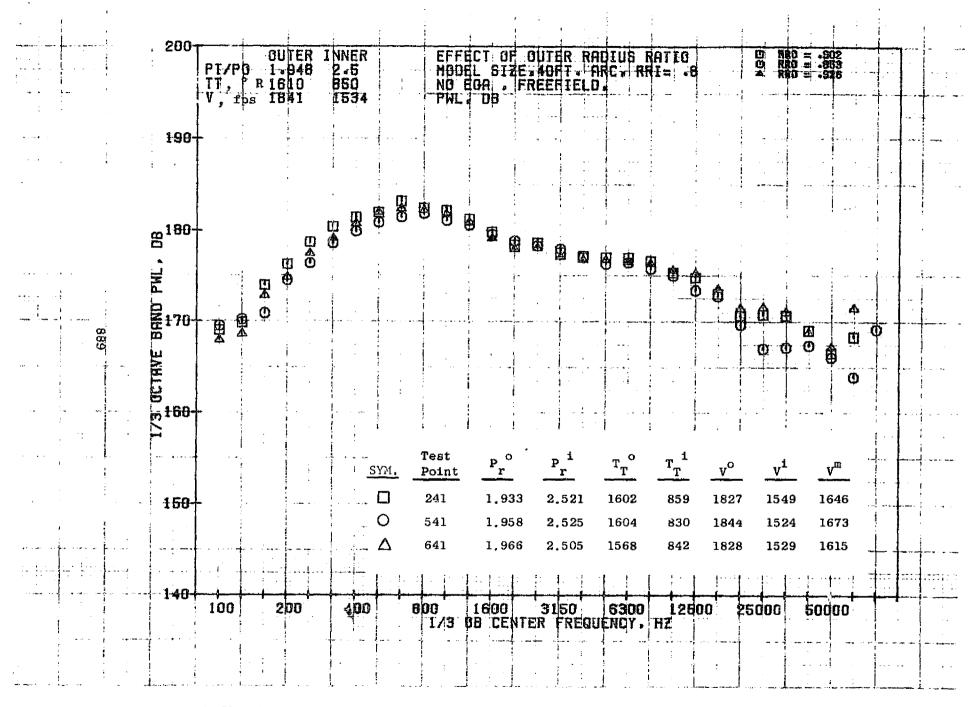


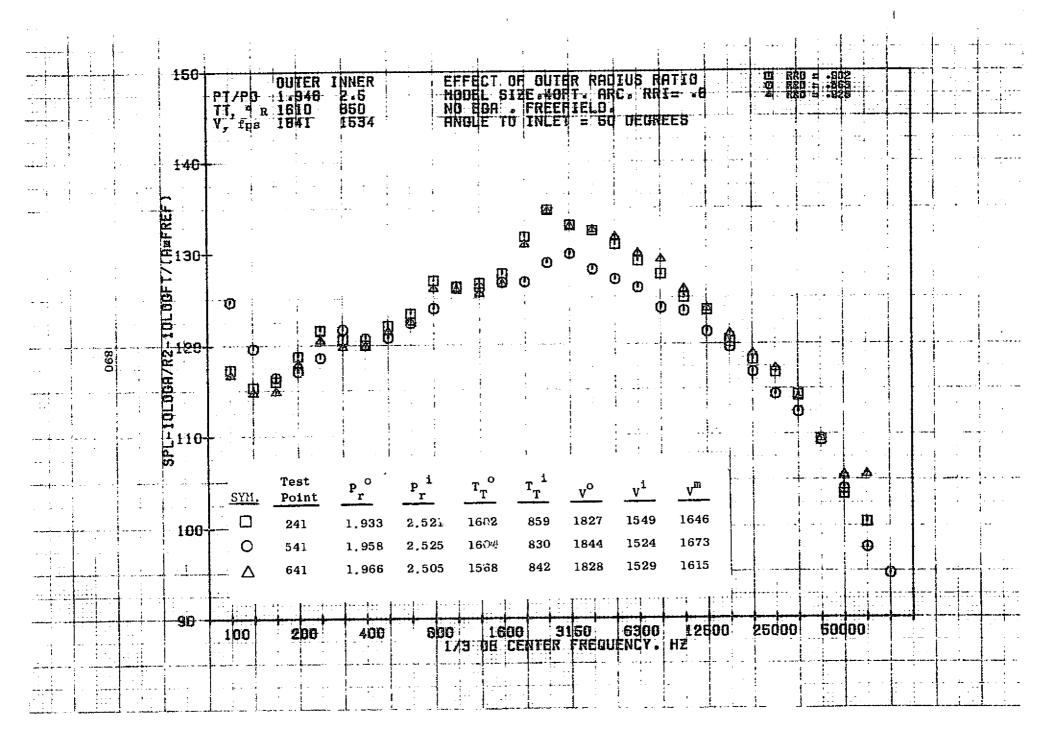


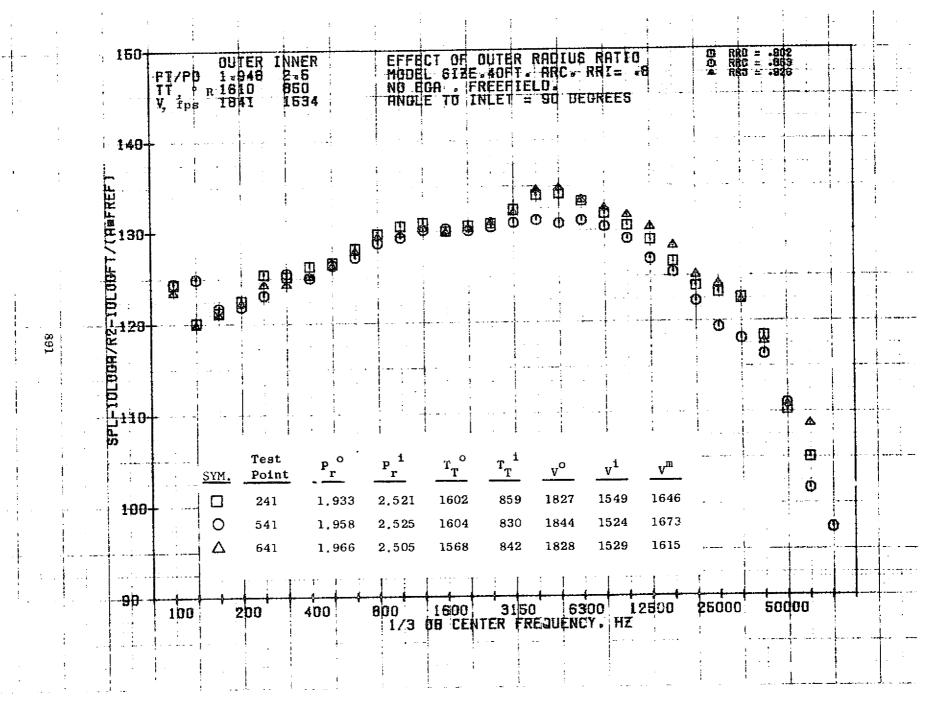
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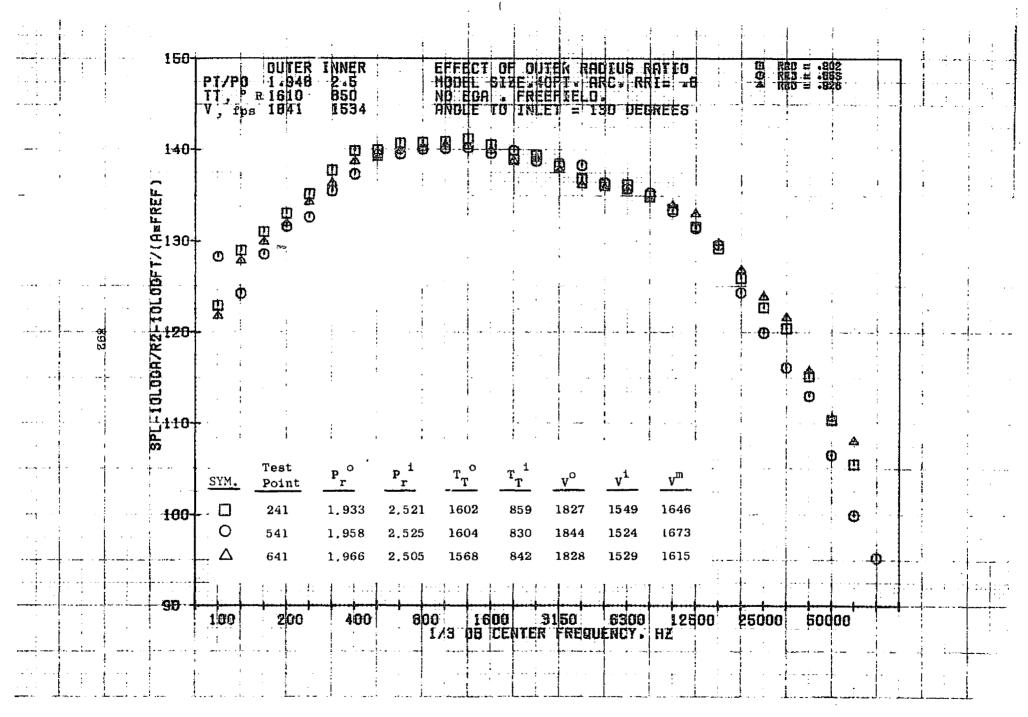


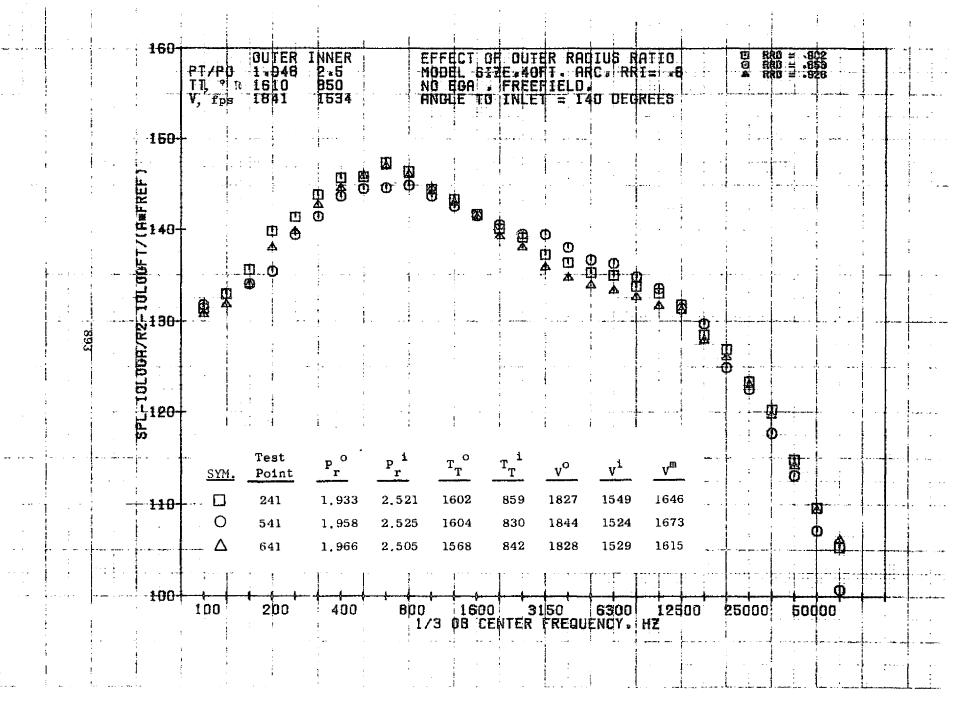


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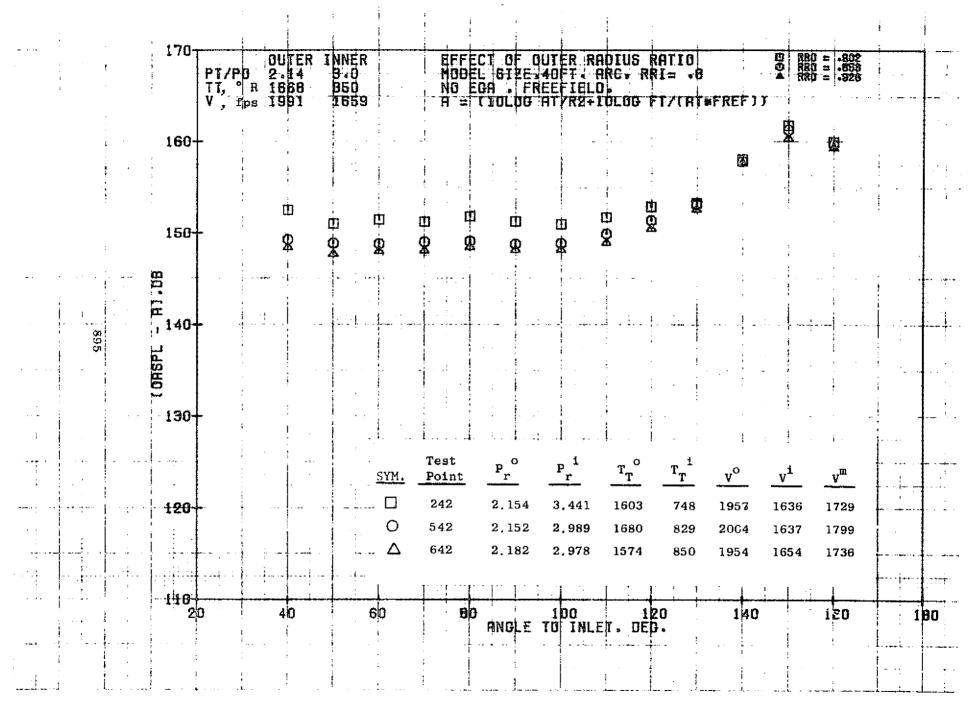
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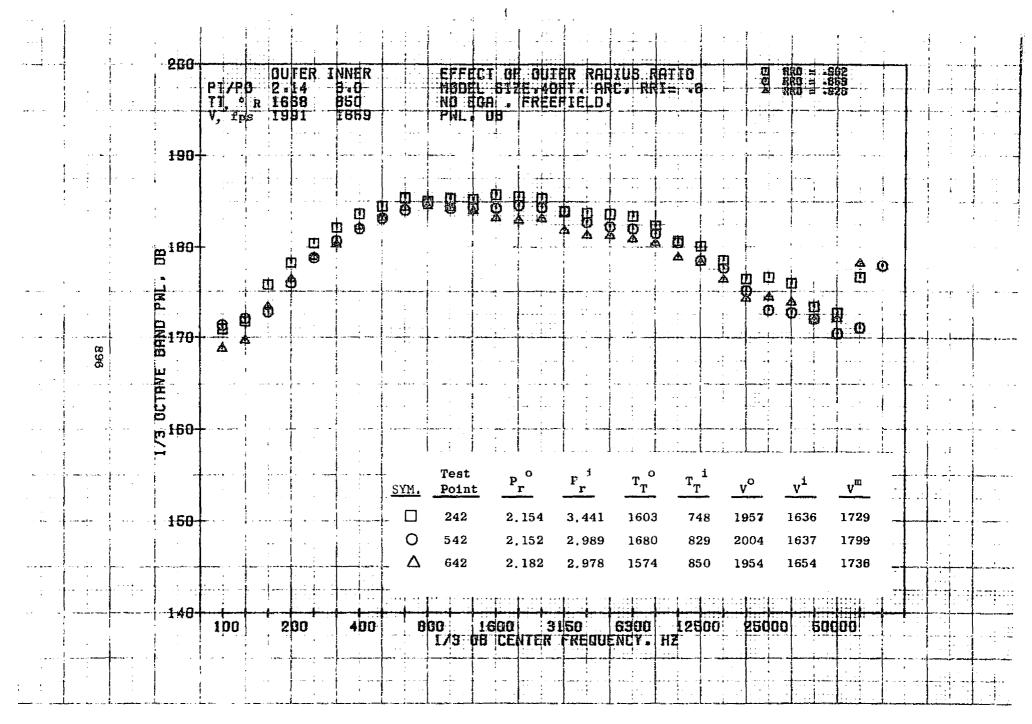




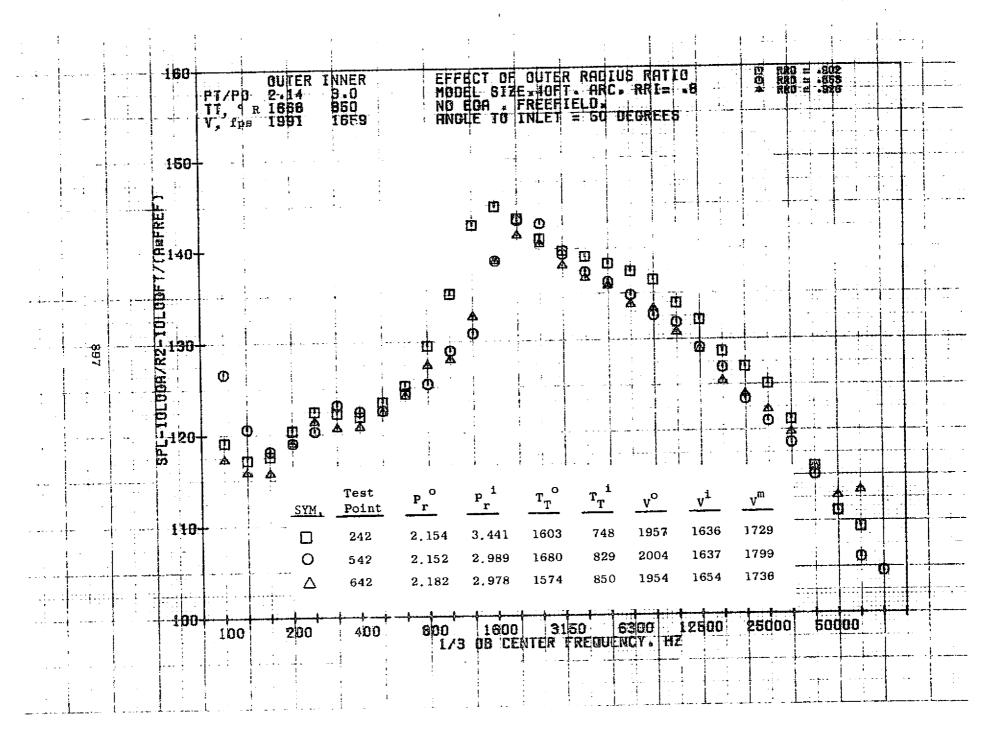
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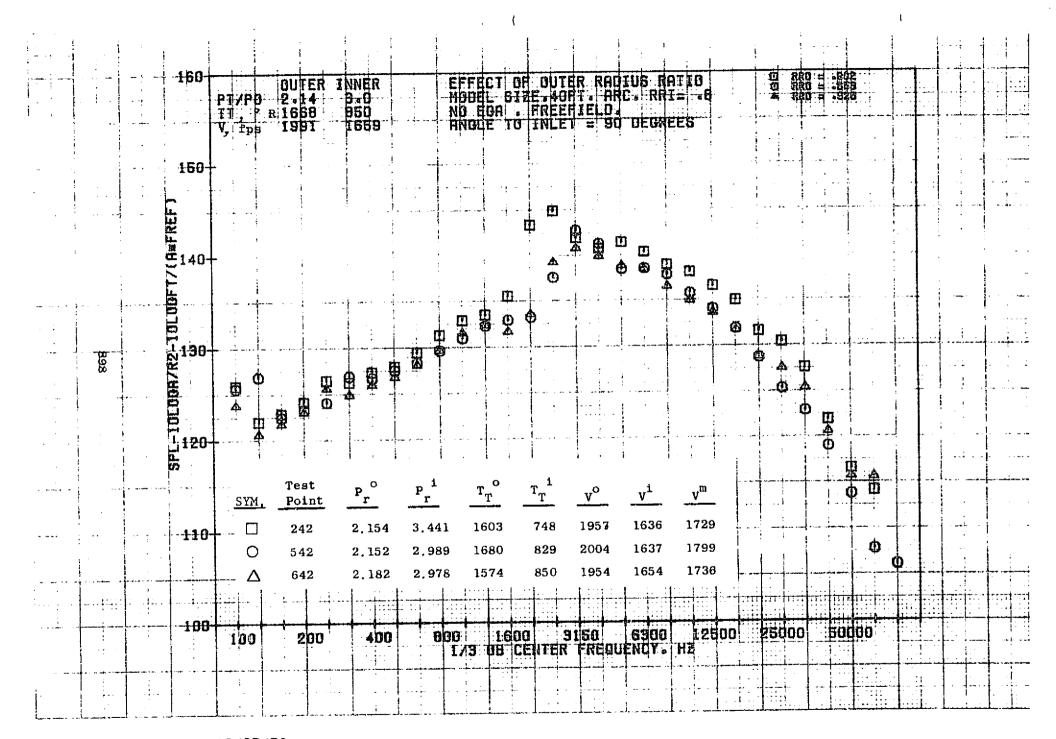
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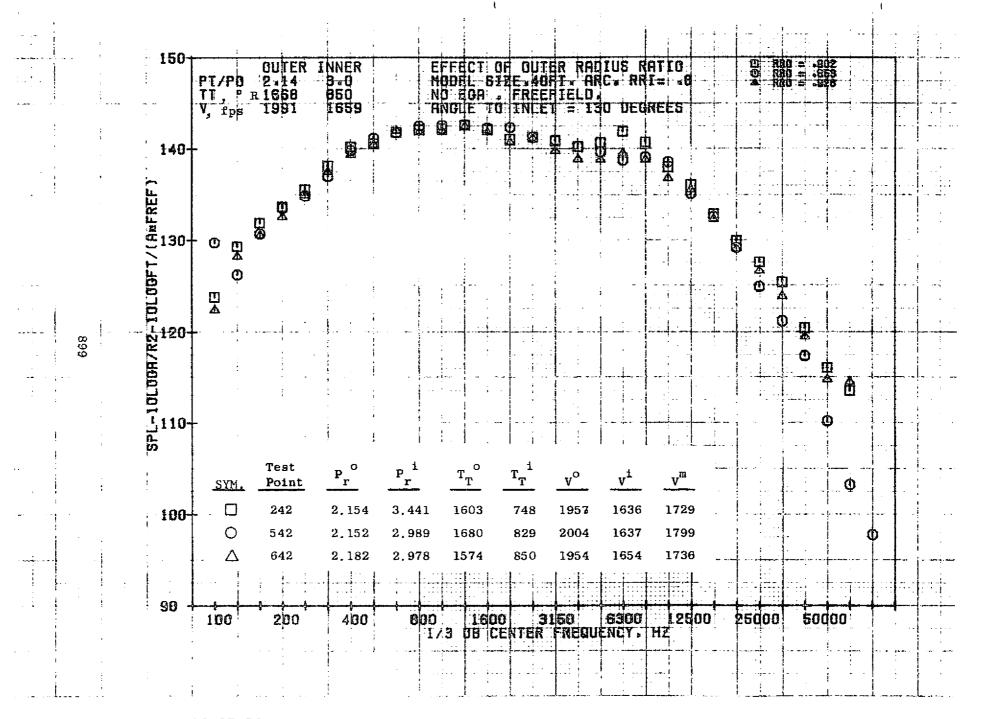




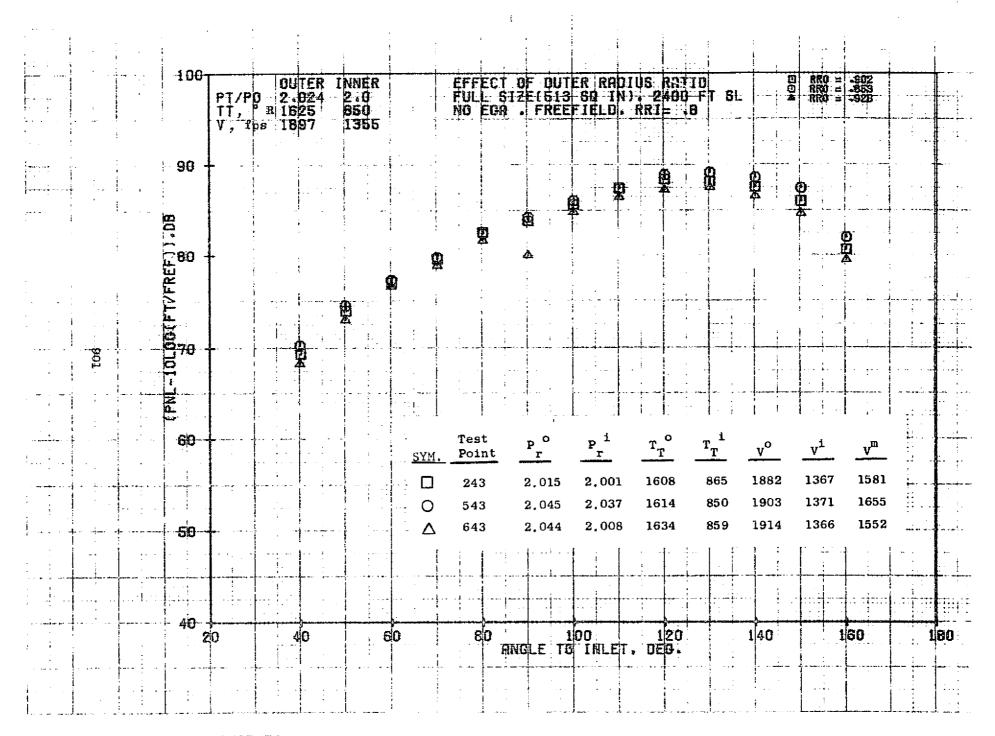
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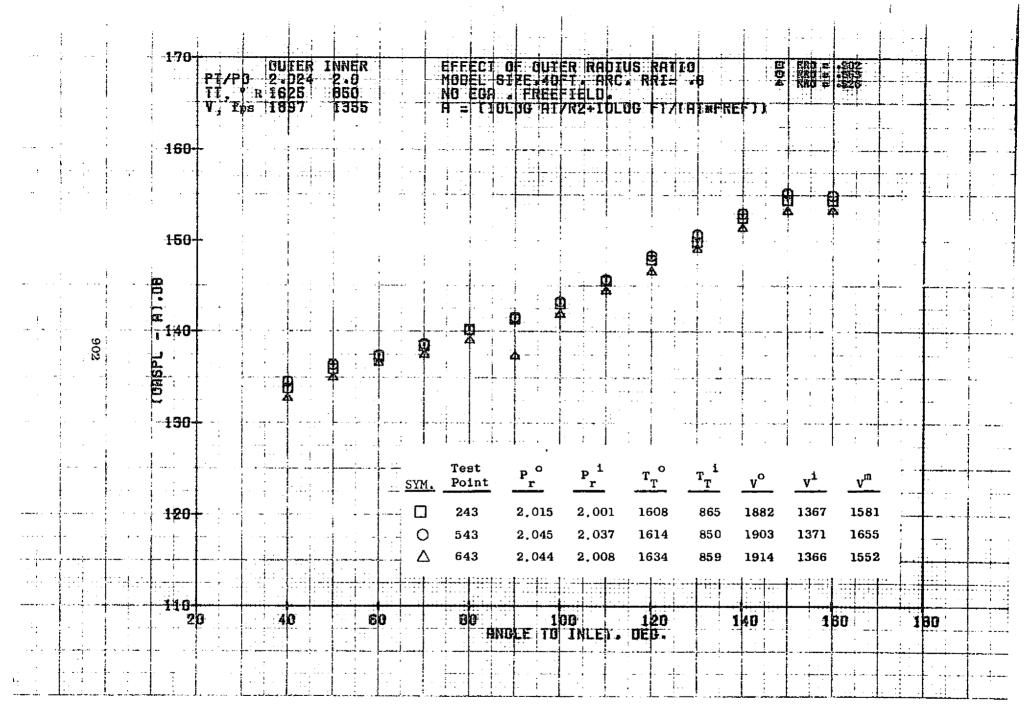


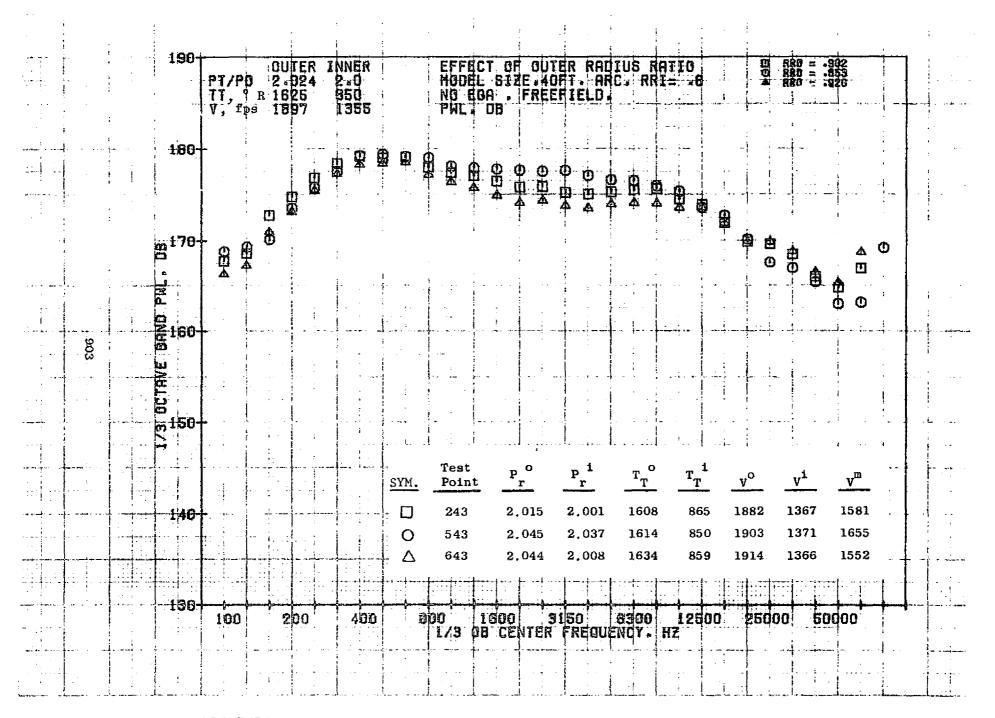


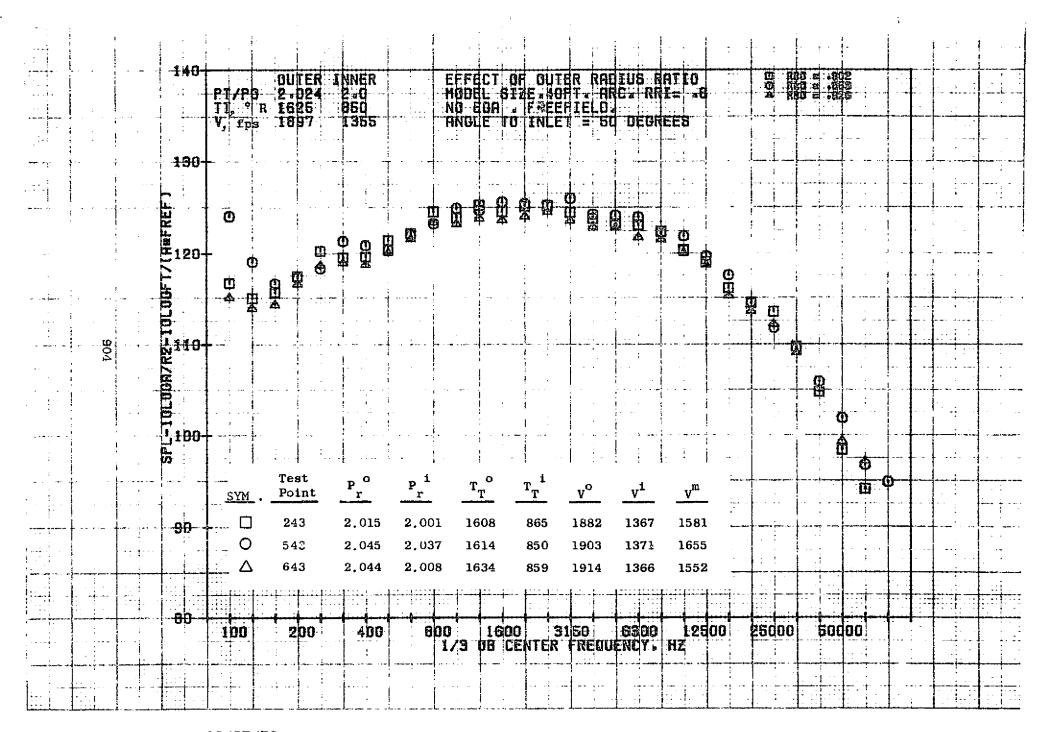


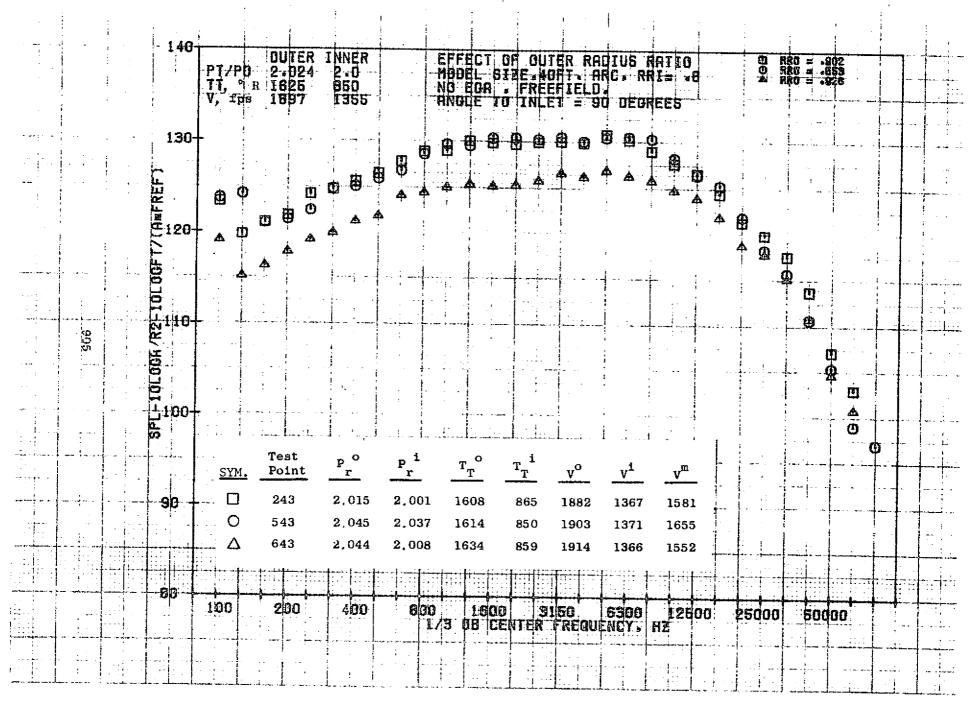
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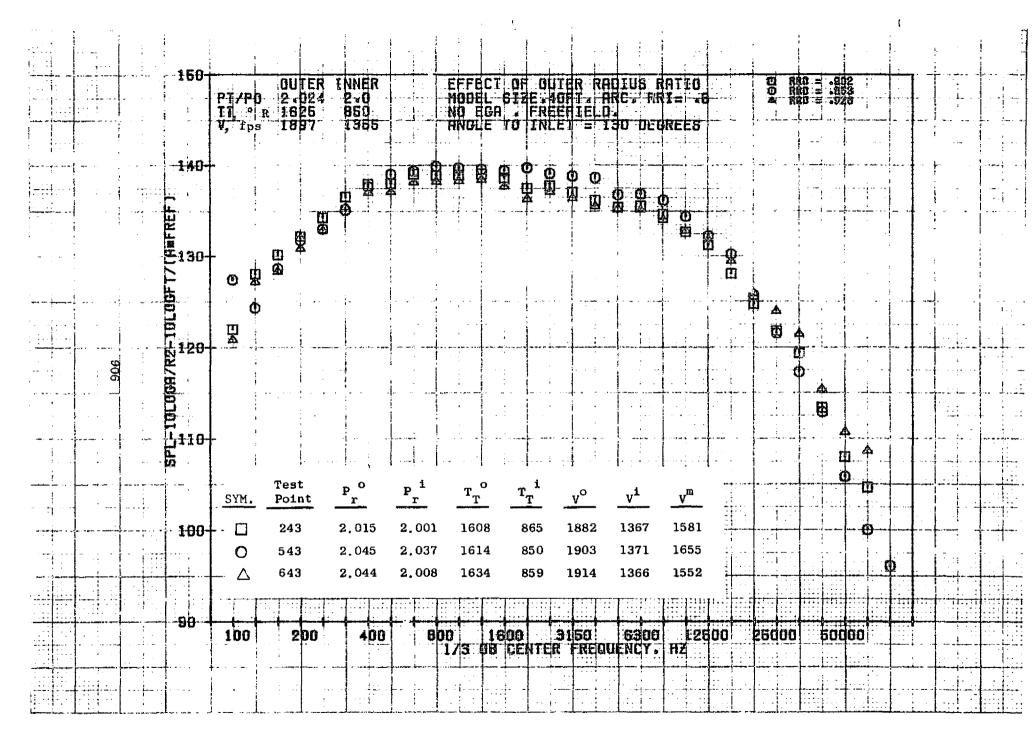


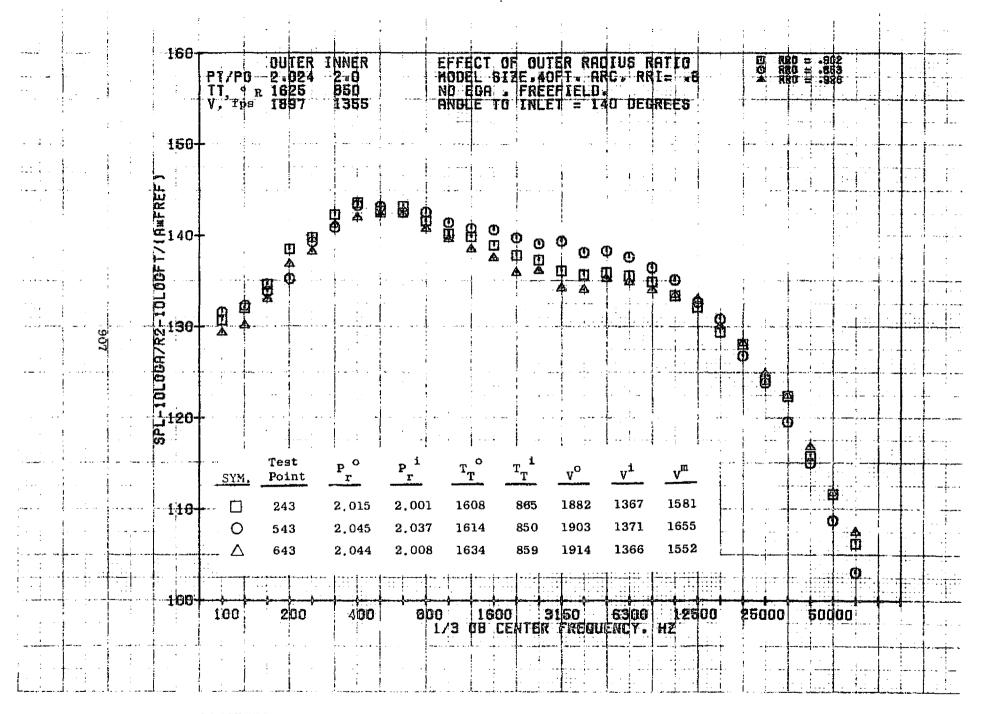






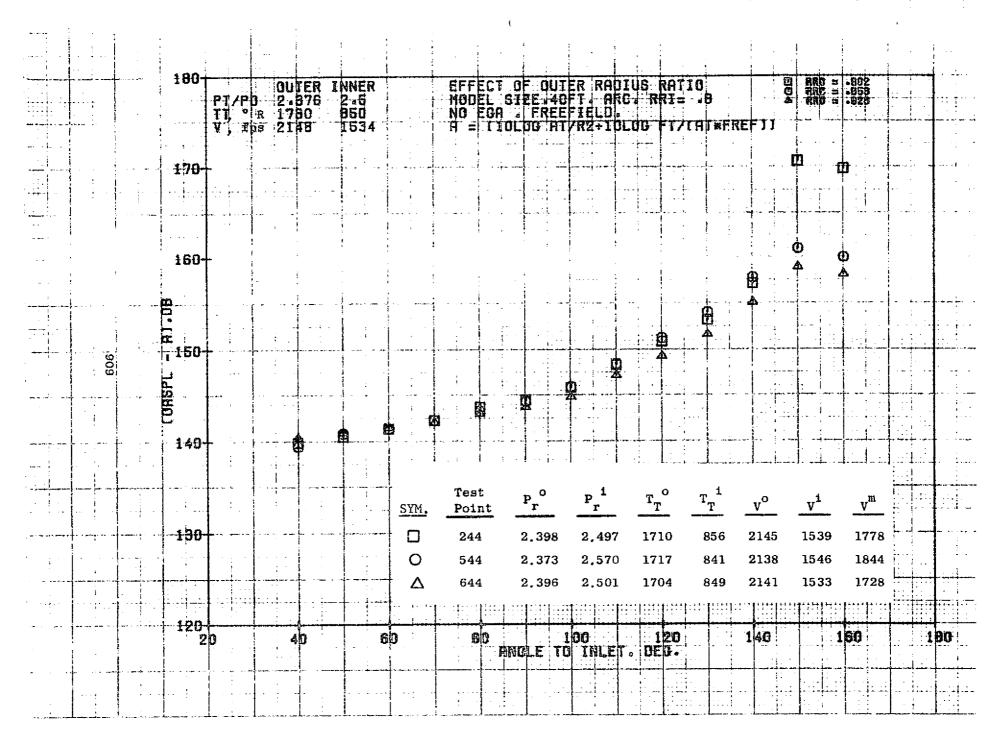




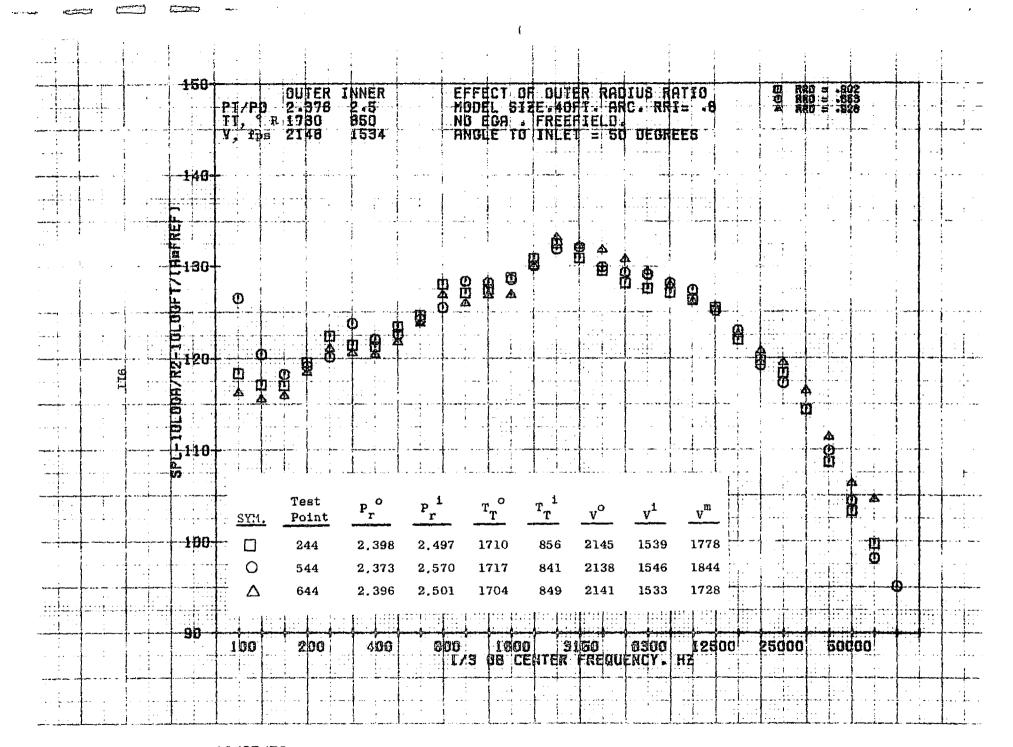


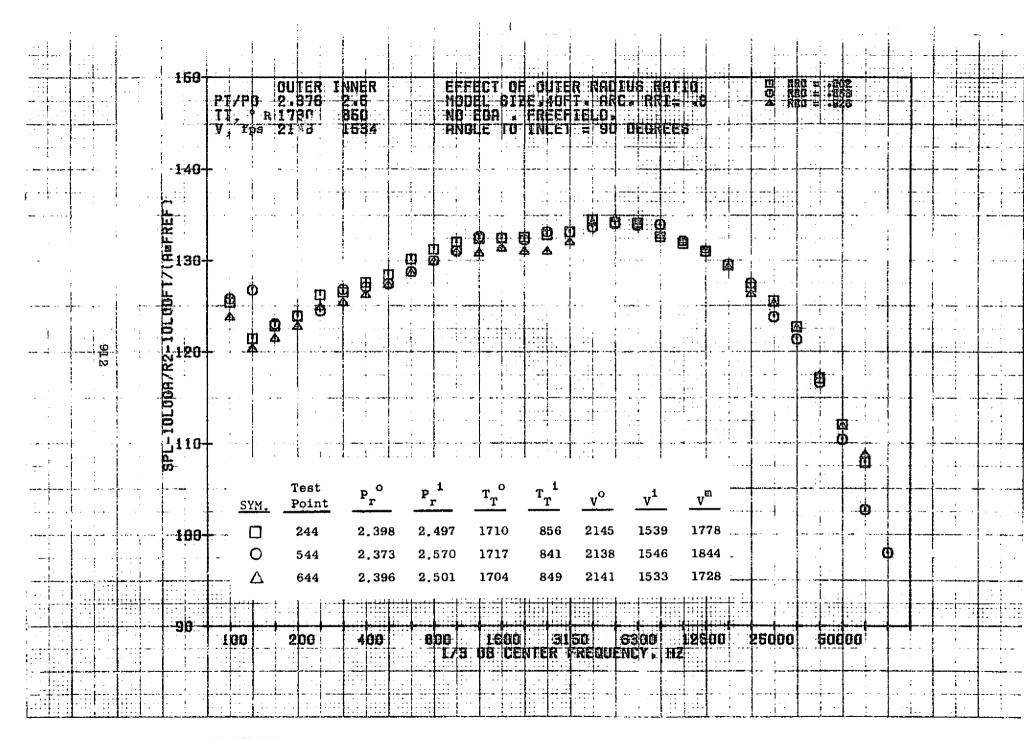
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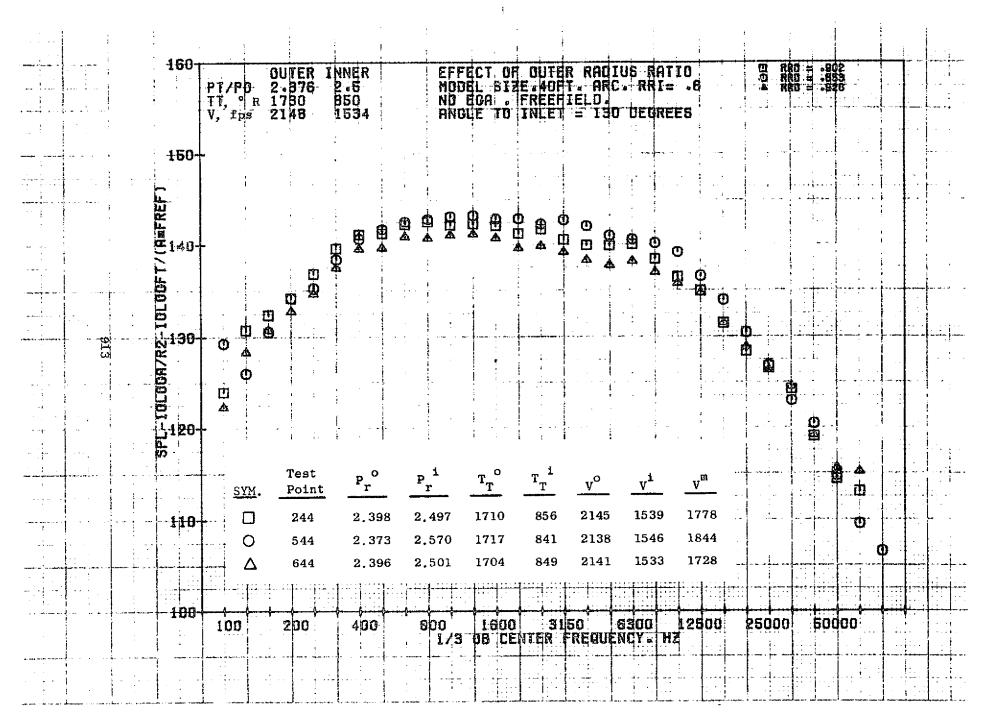
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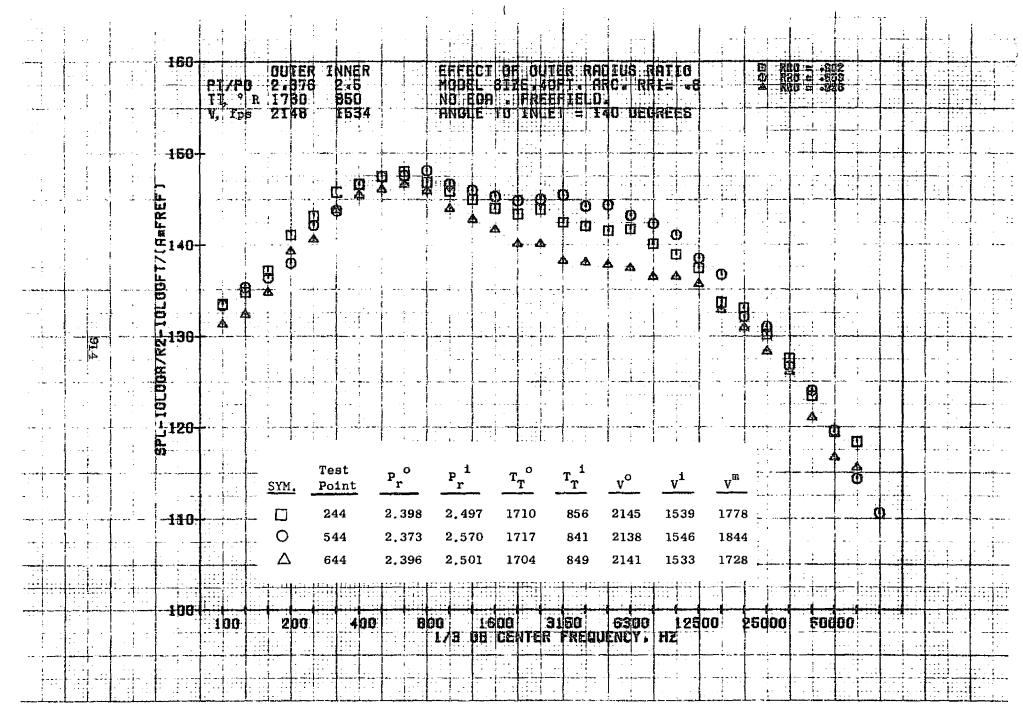


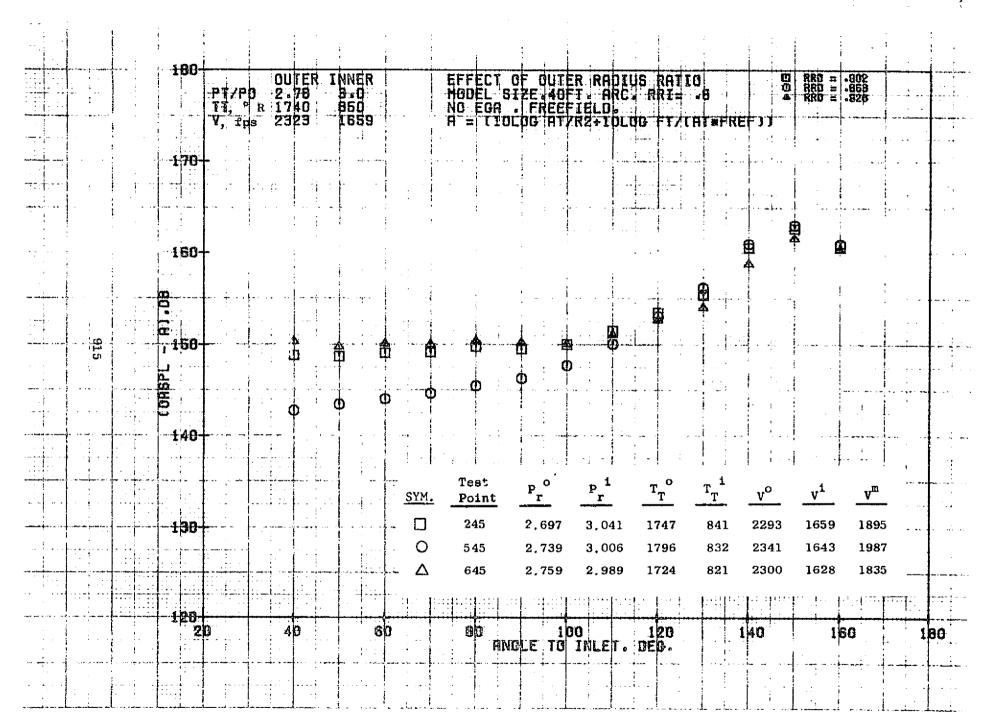
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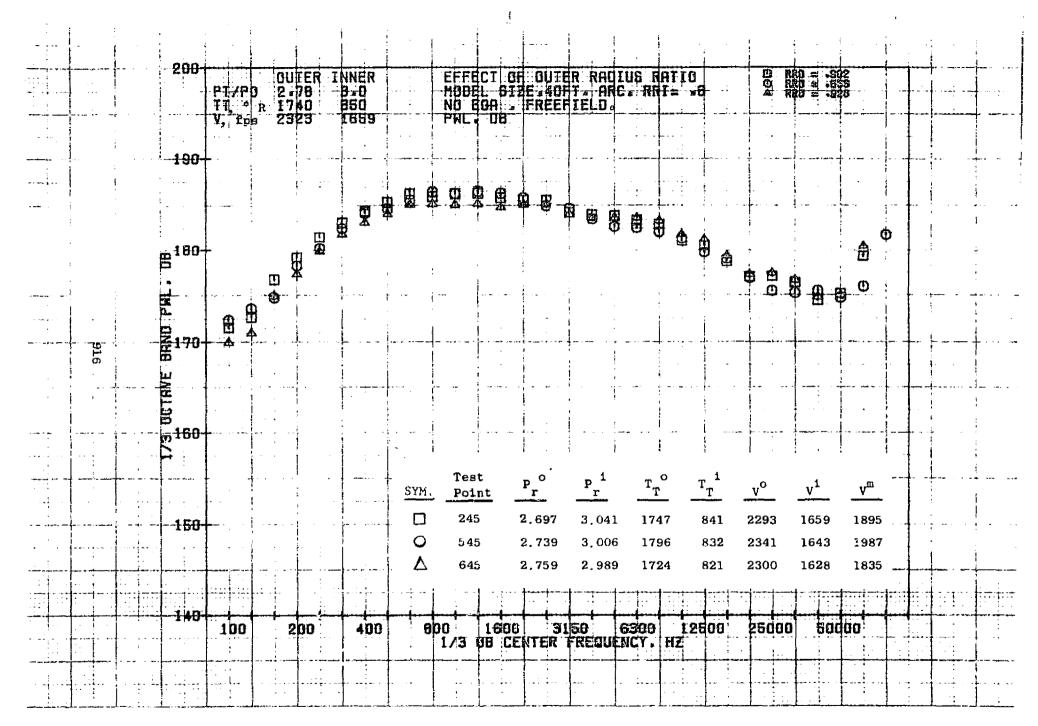


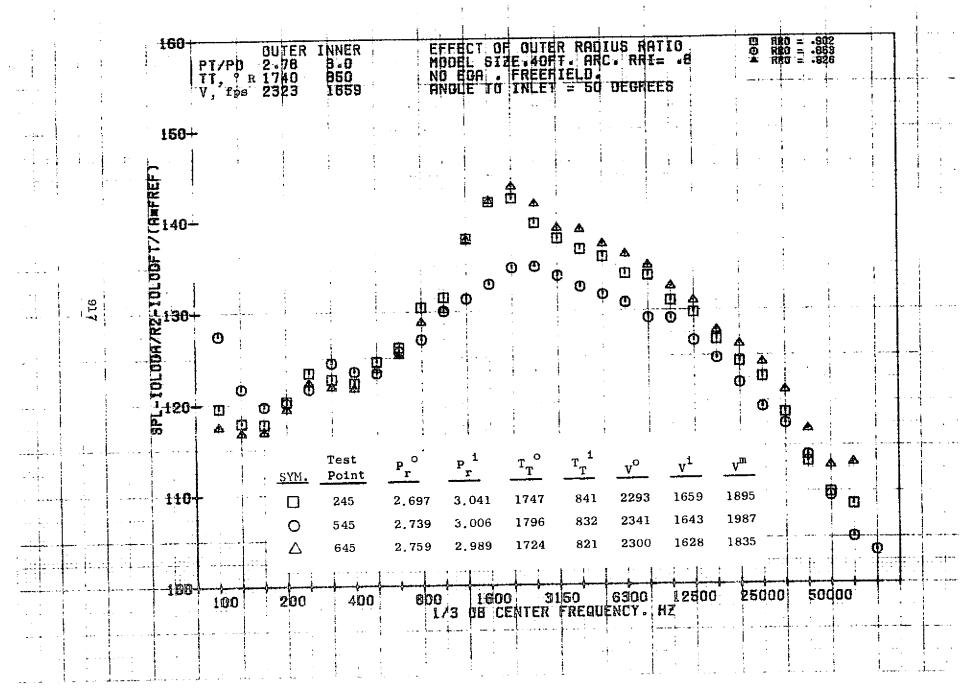


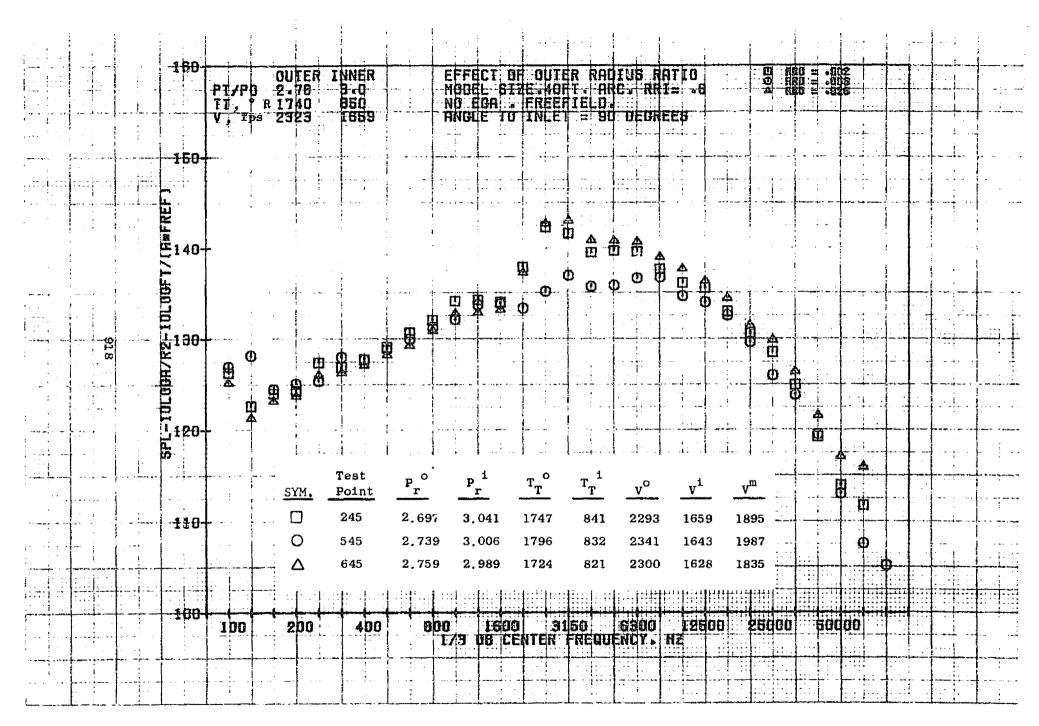


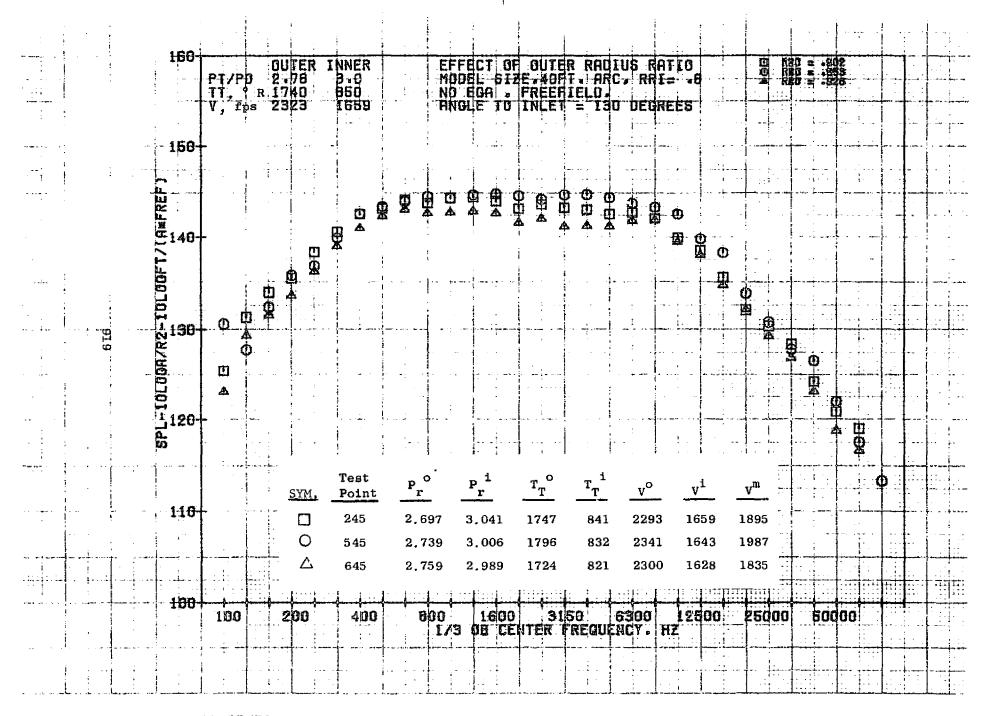


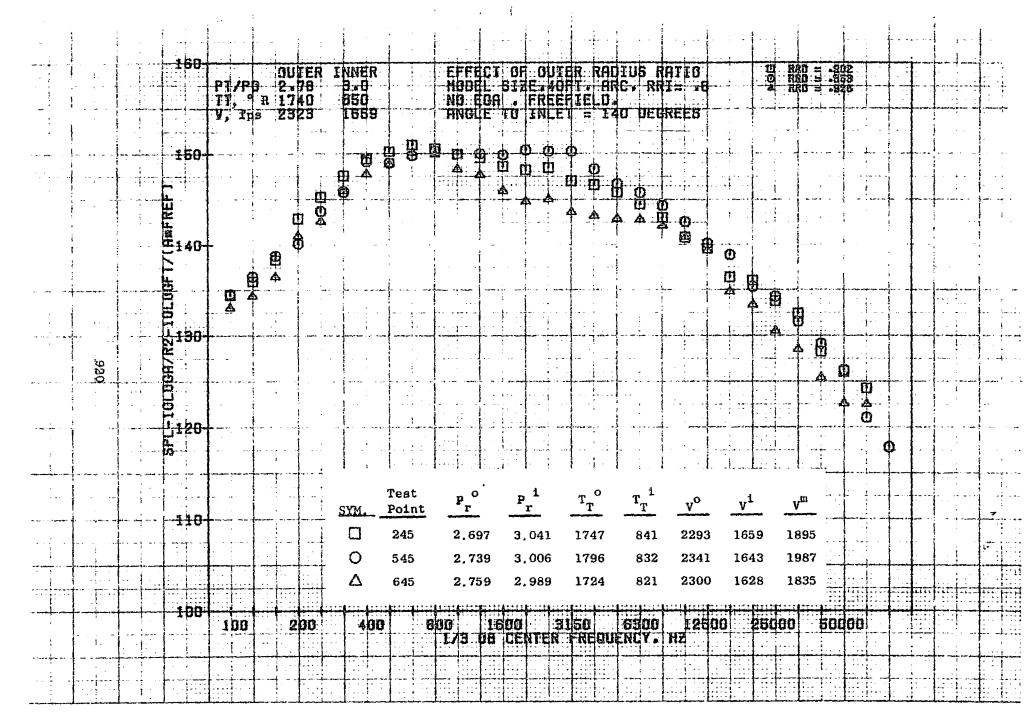




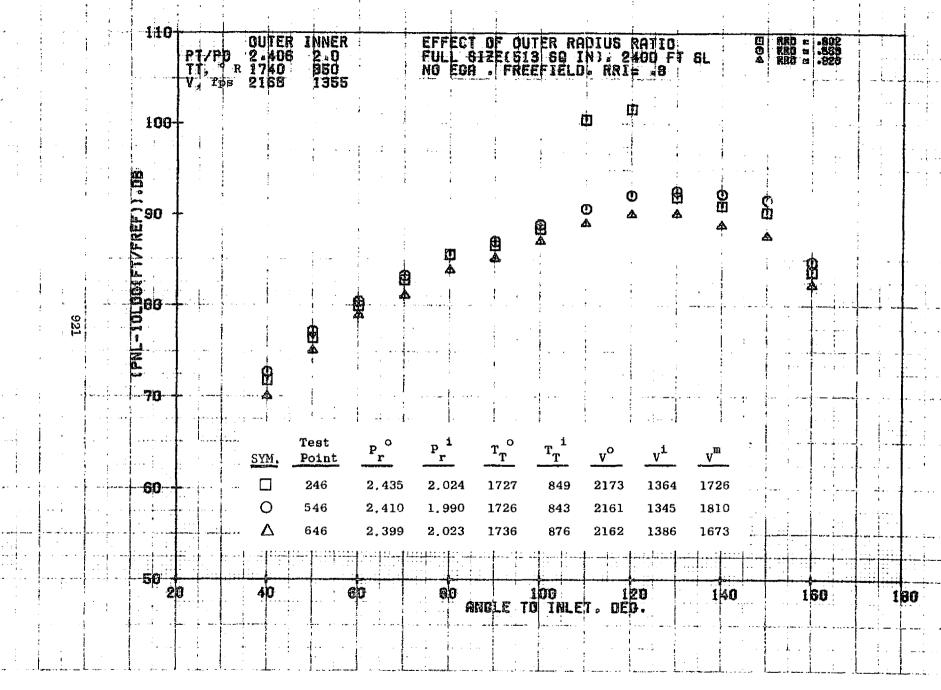


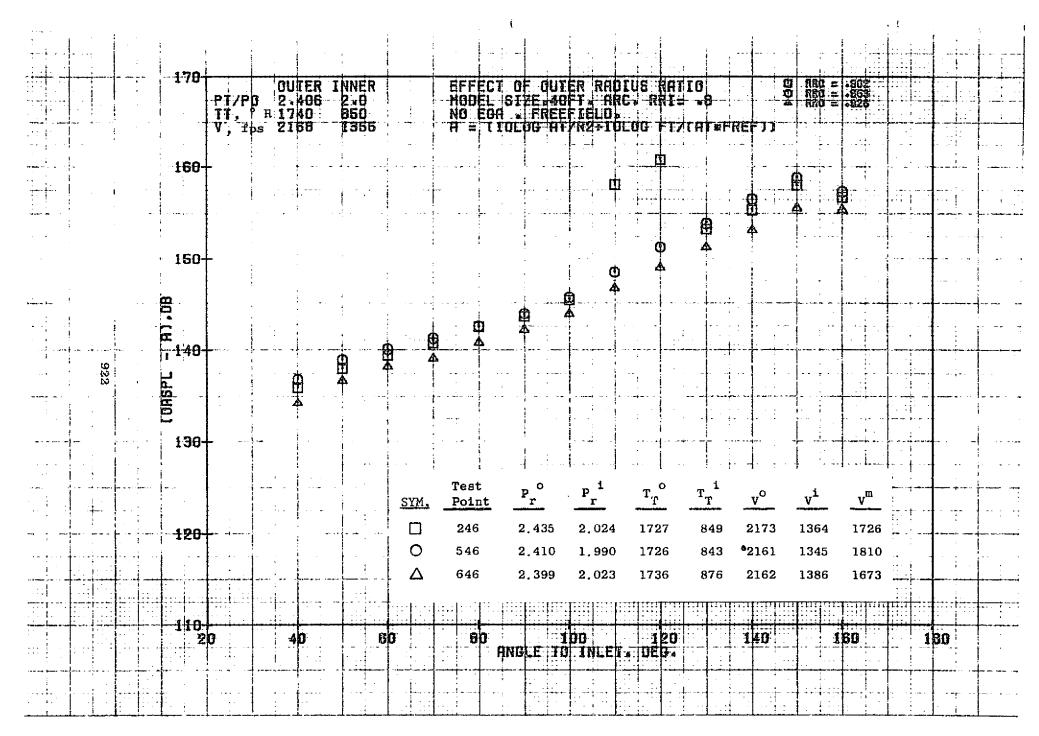




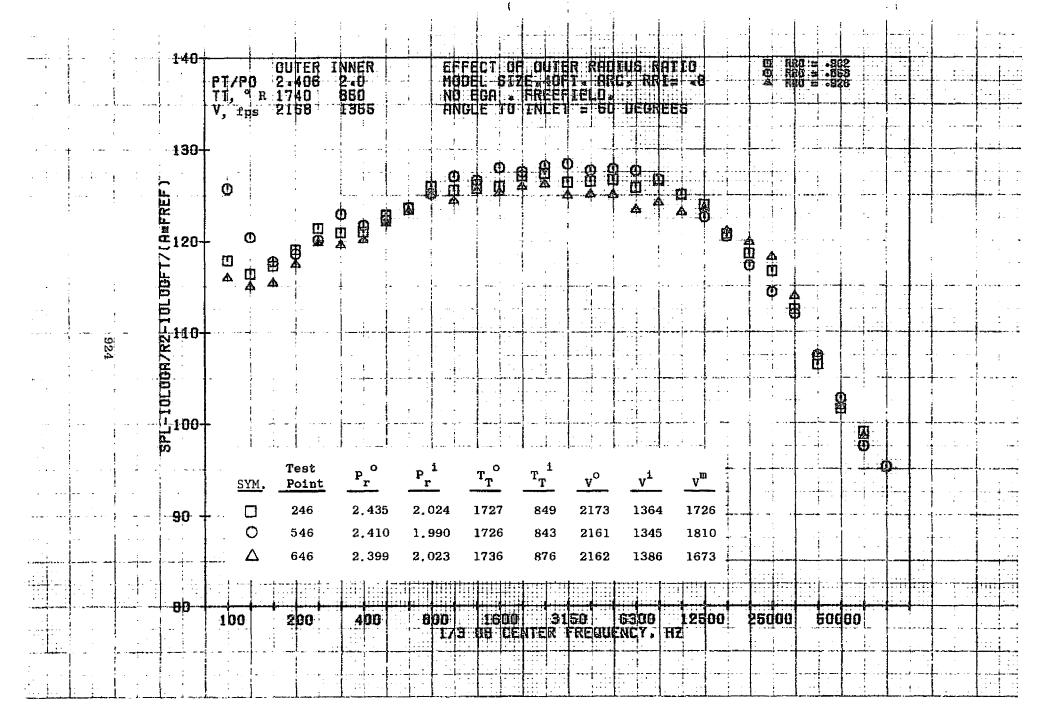


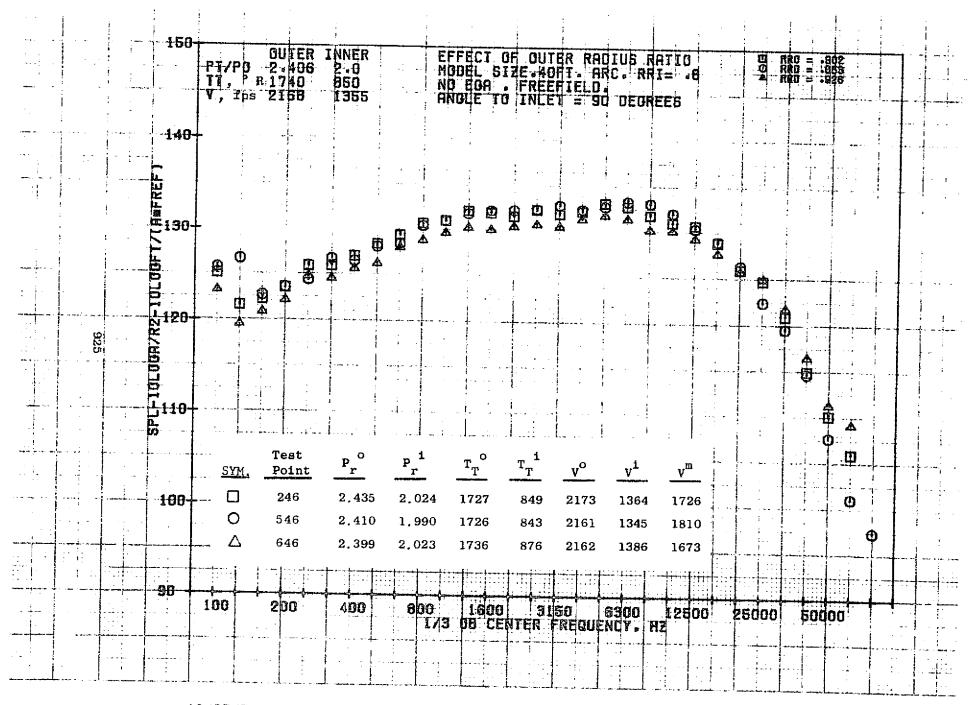
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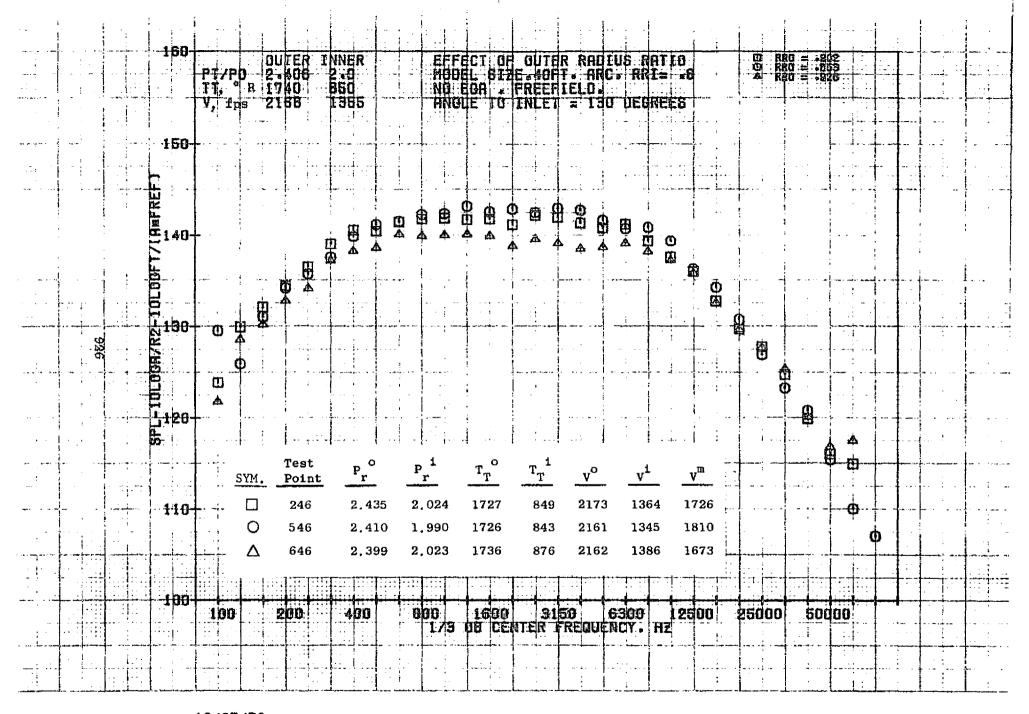


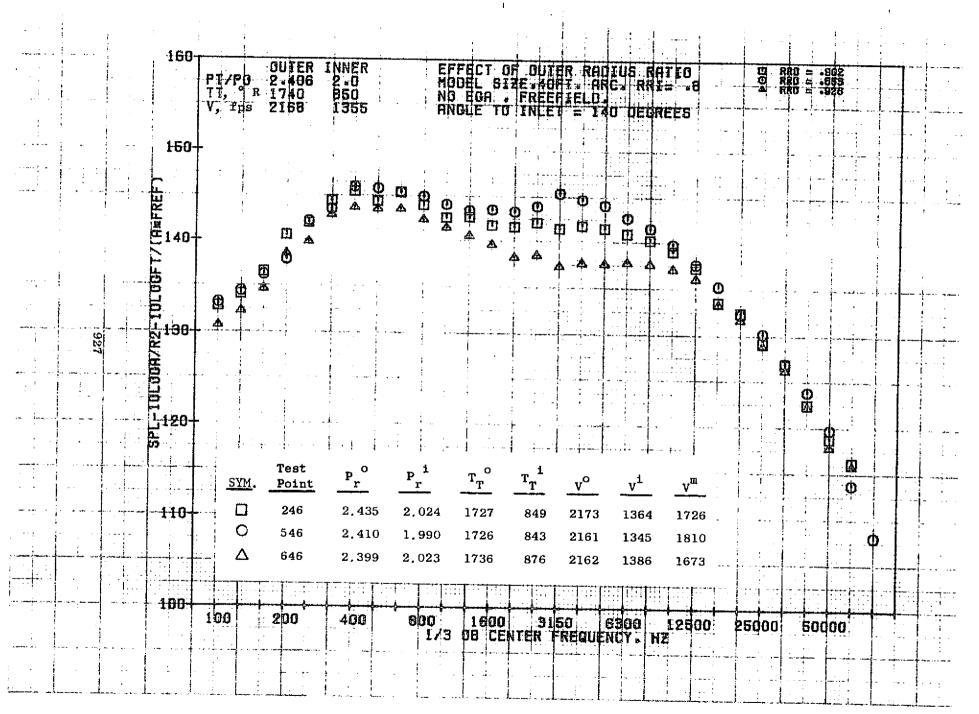


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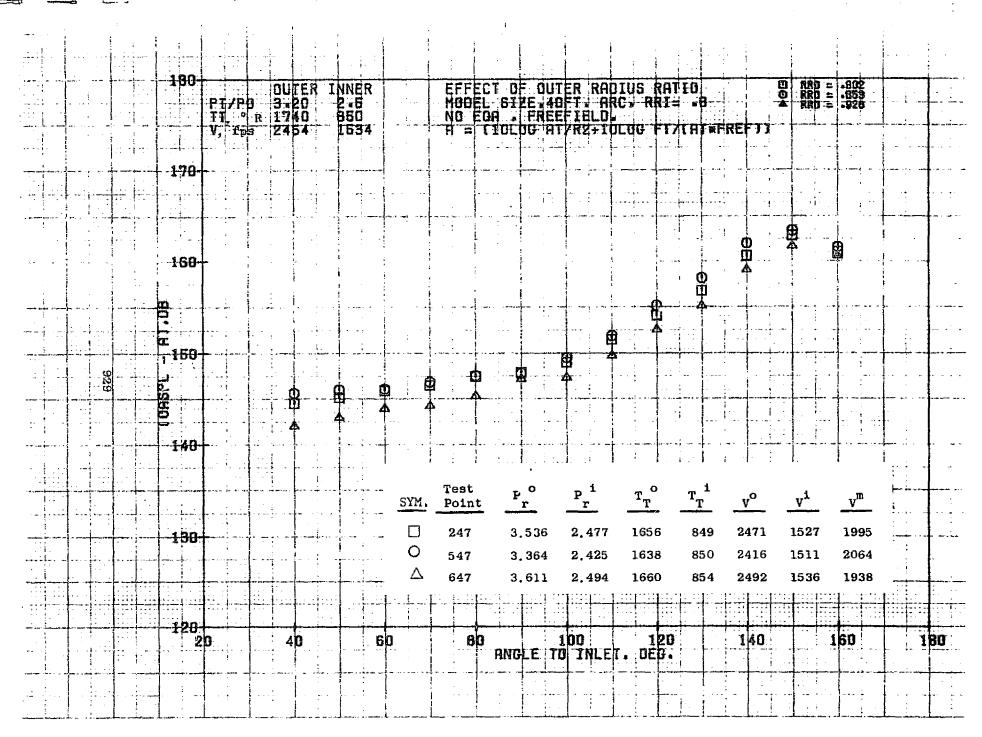




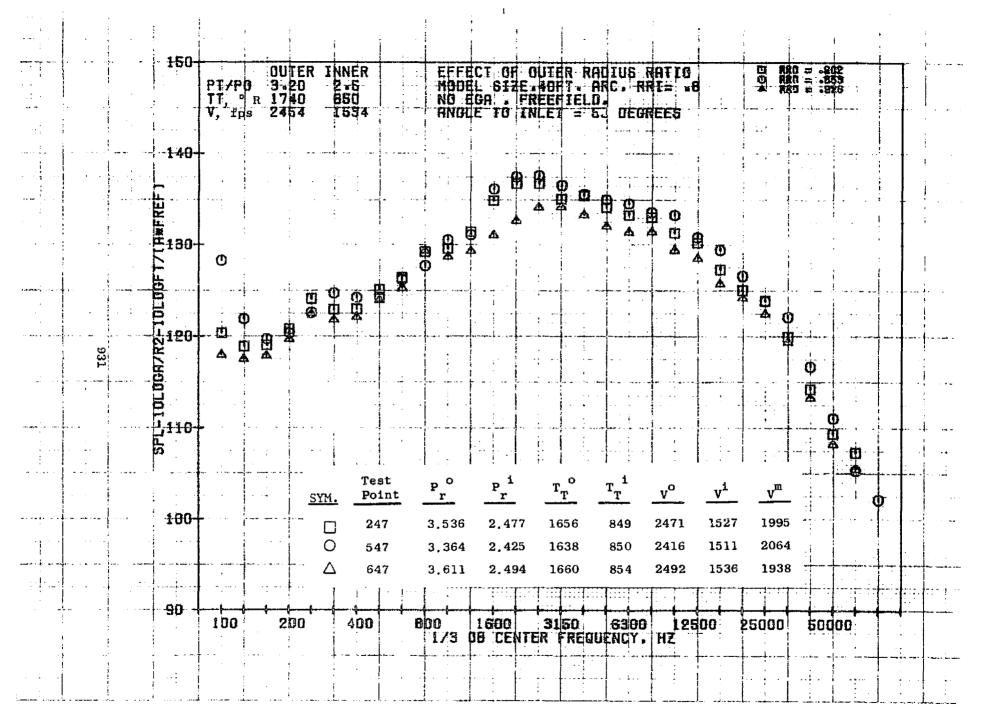


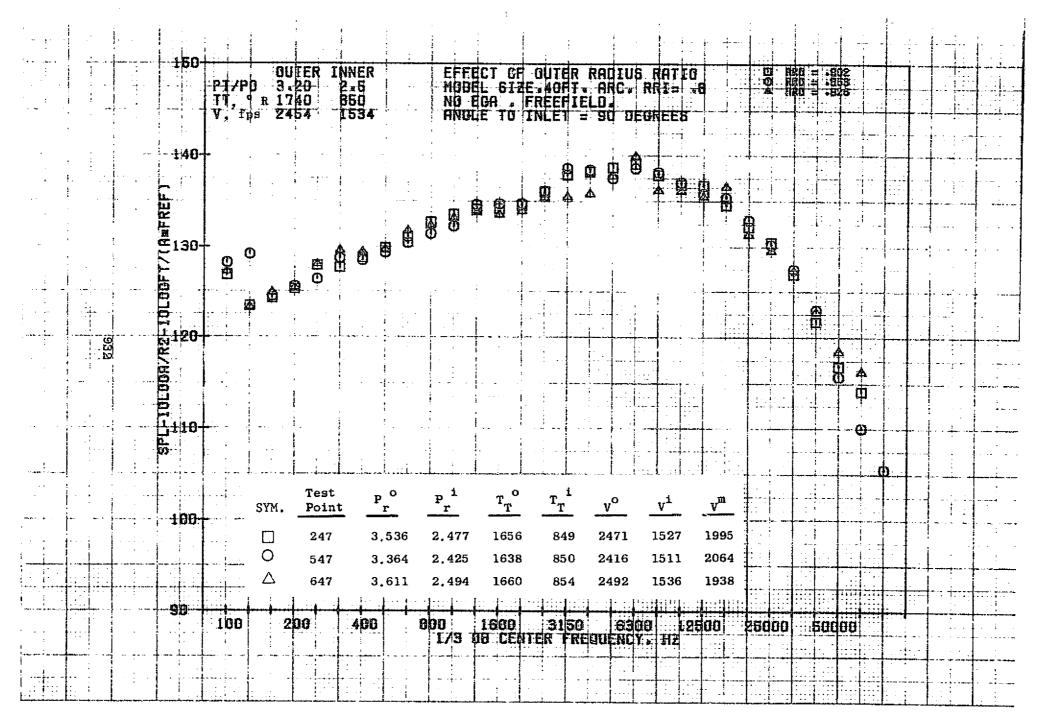


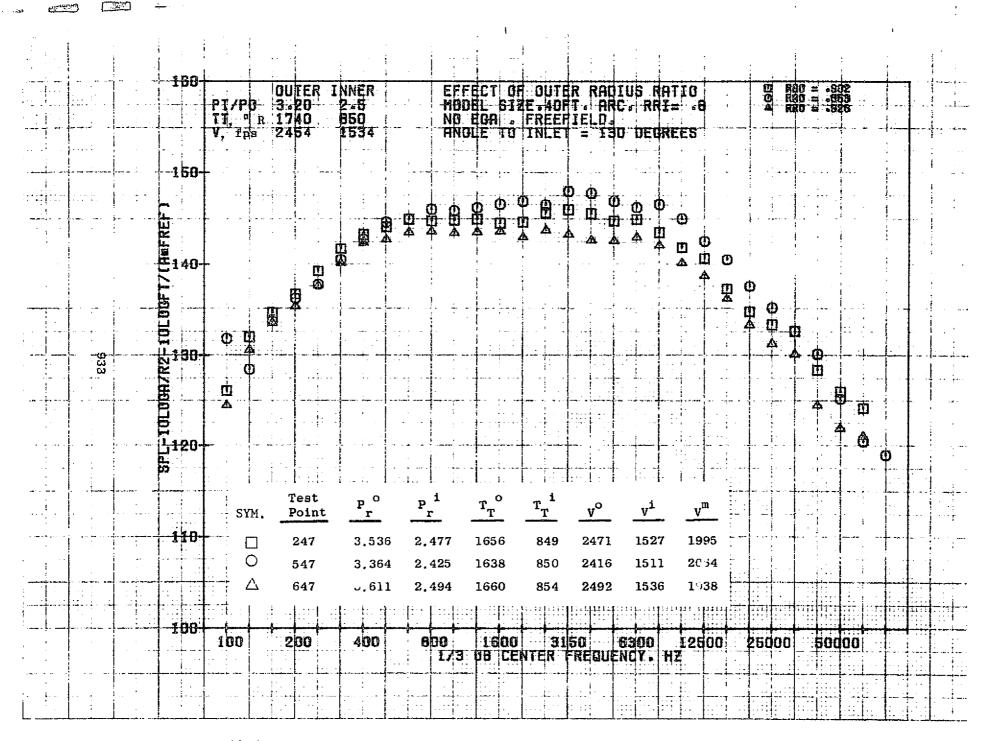
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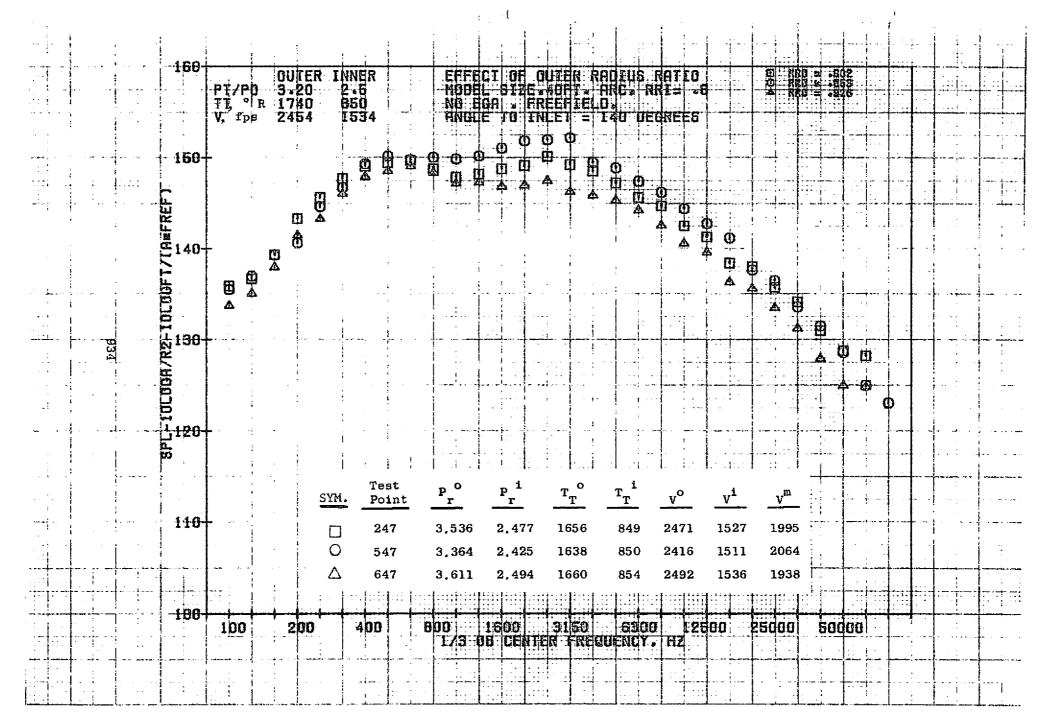


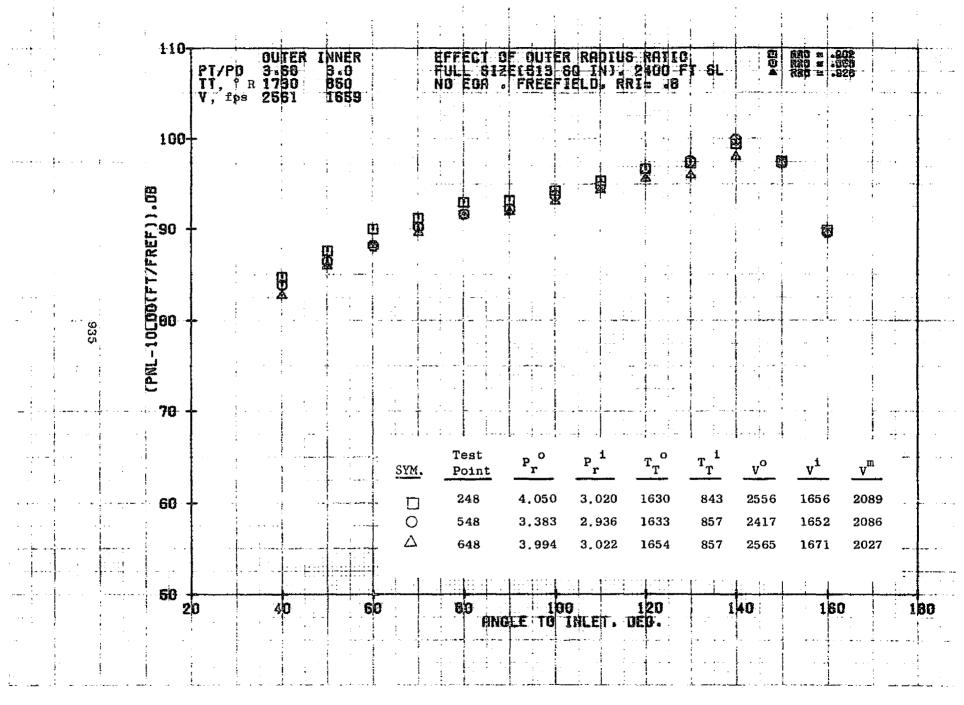
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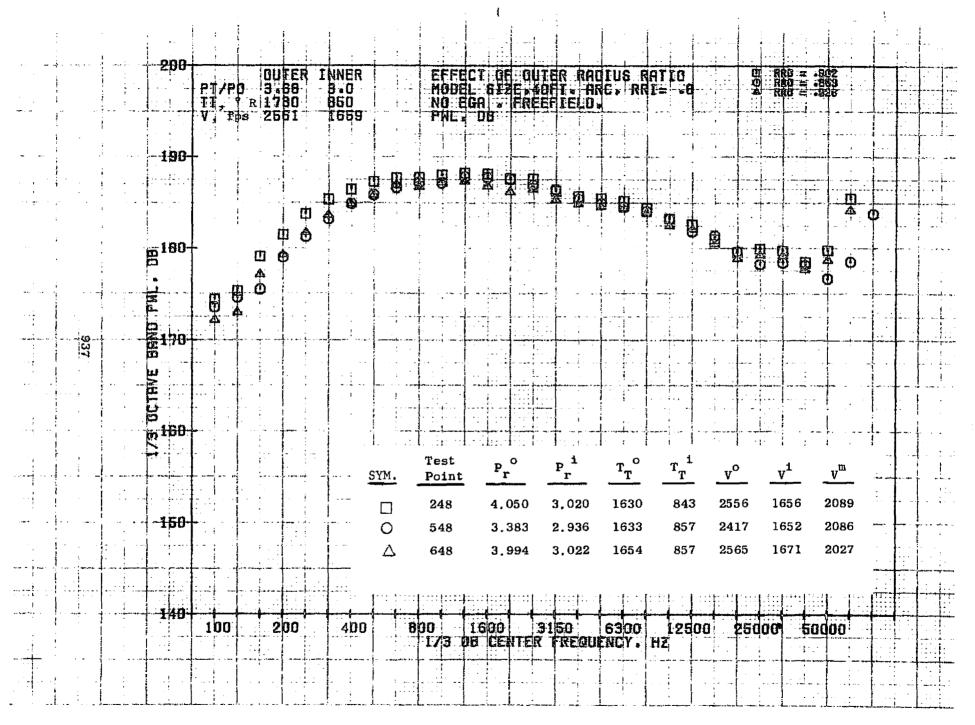


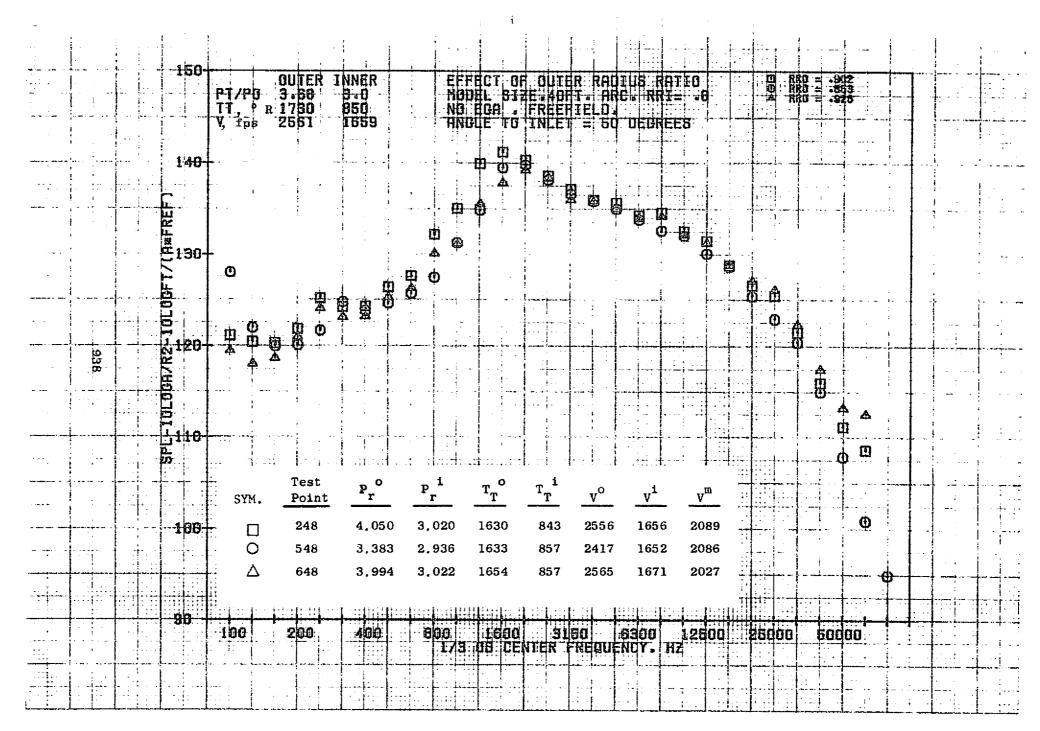


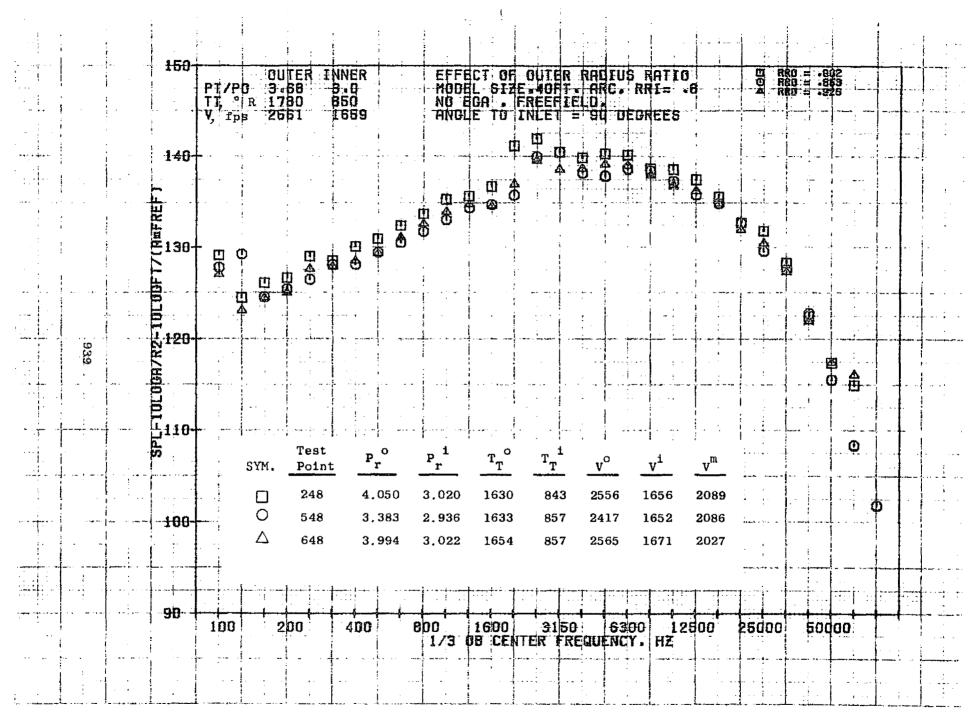




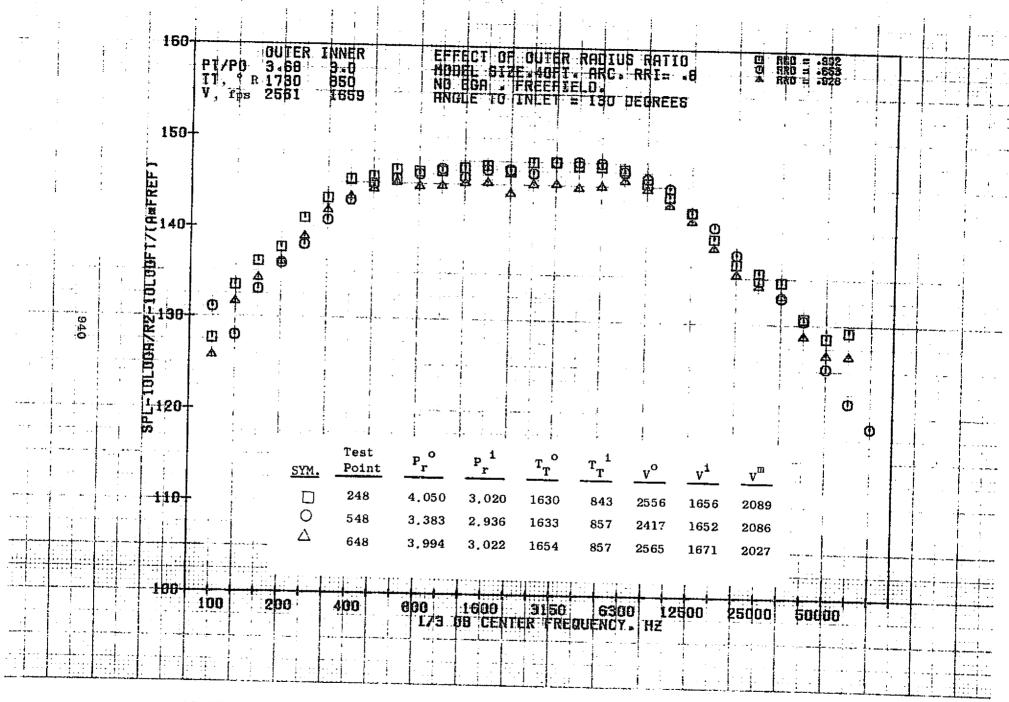
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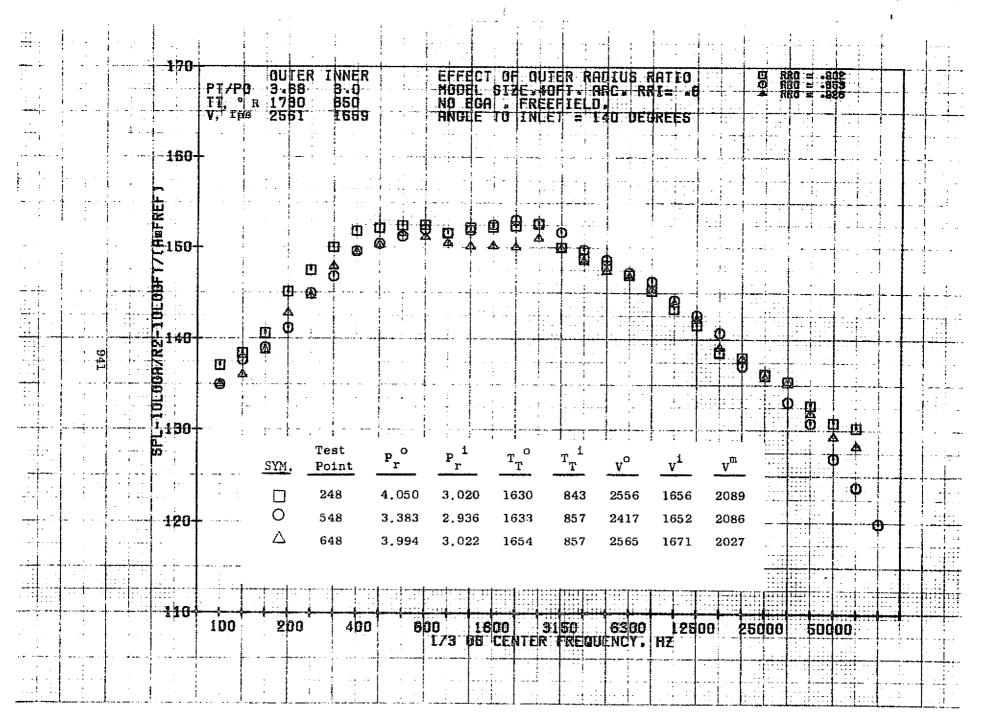






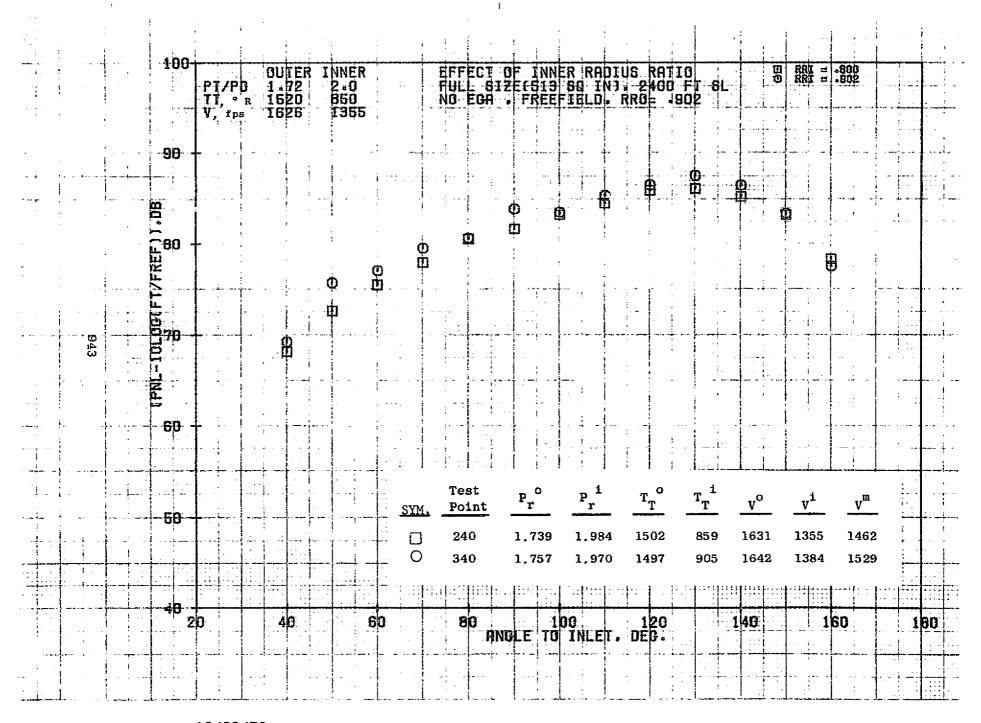
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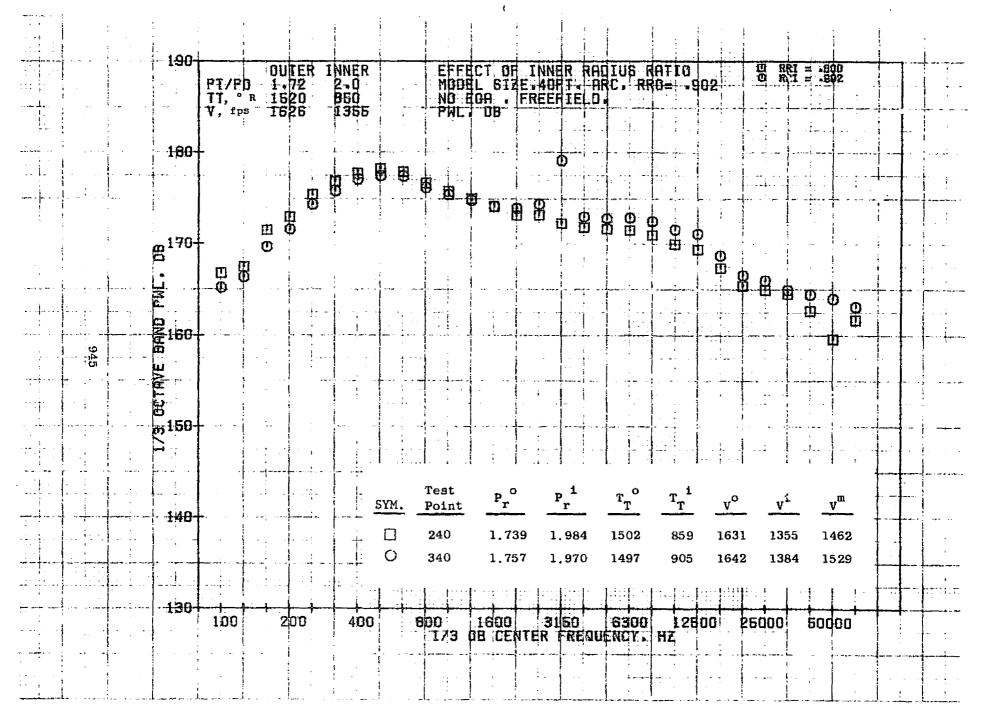


7.4.2 Effect of Inner Radius Ratio

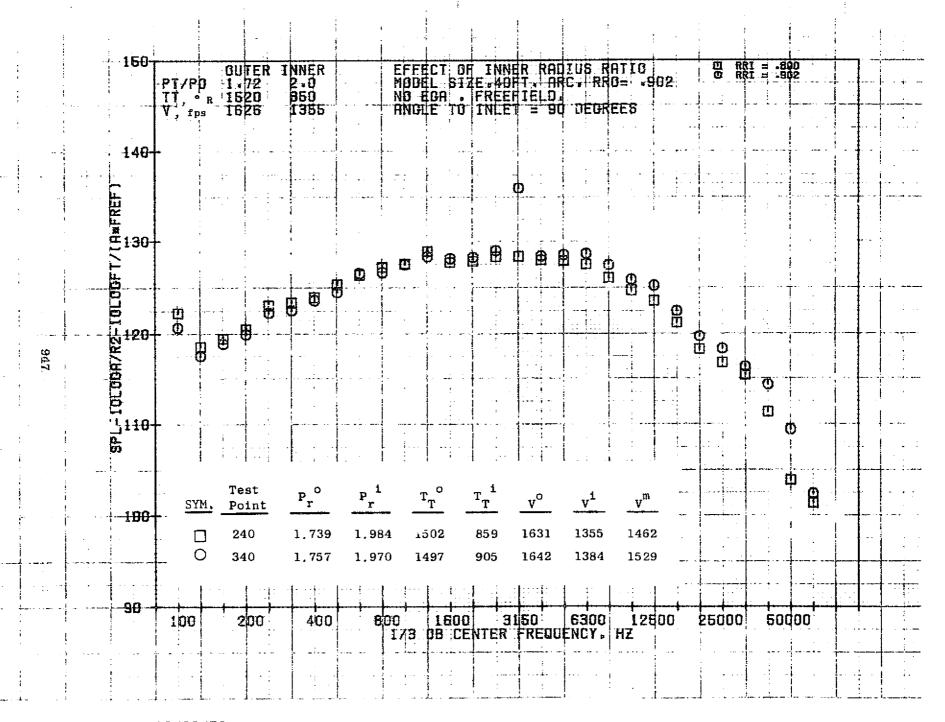
Configurations 2 and 3 have the same outer radius ratio (0.902) but different inner radius ratios, 0.800 and 0.902, respectively. The acoustic results are compared in this section. Configurations 5 and 7 are also compared. These two configurations have a 0.853 outer radius ratio and inner radius ratios of 0.800 and 0.902, respectively.

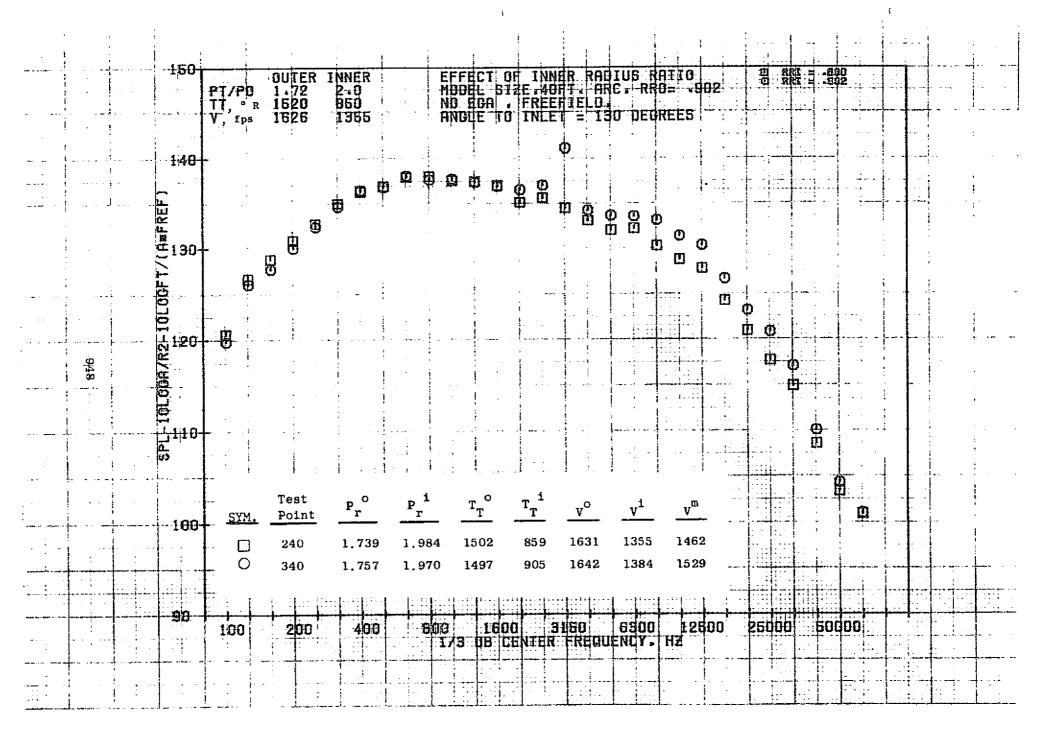


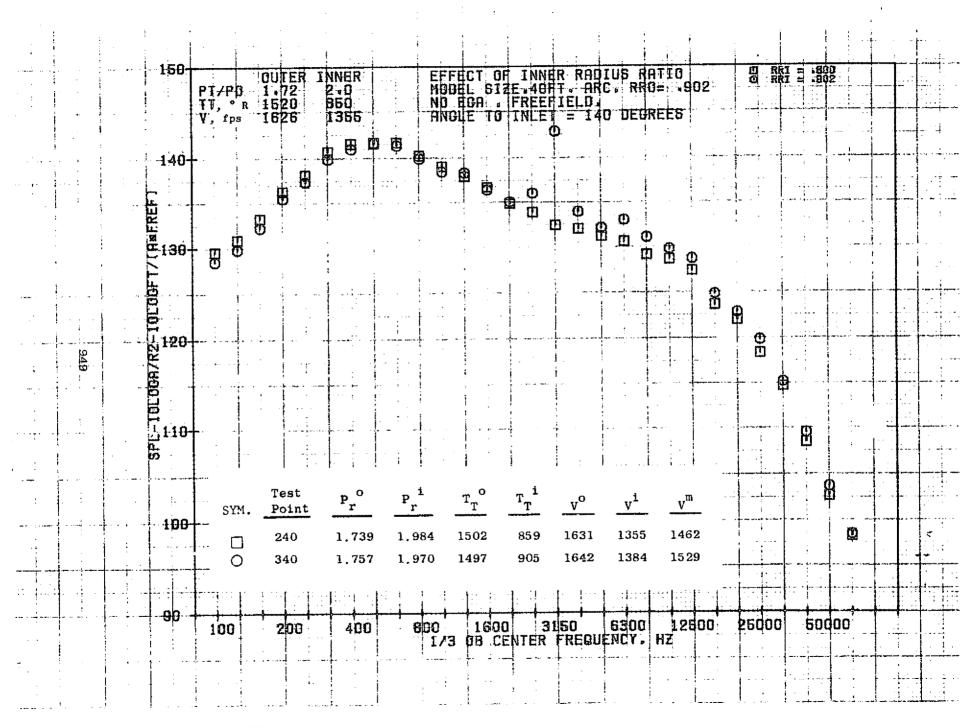
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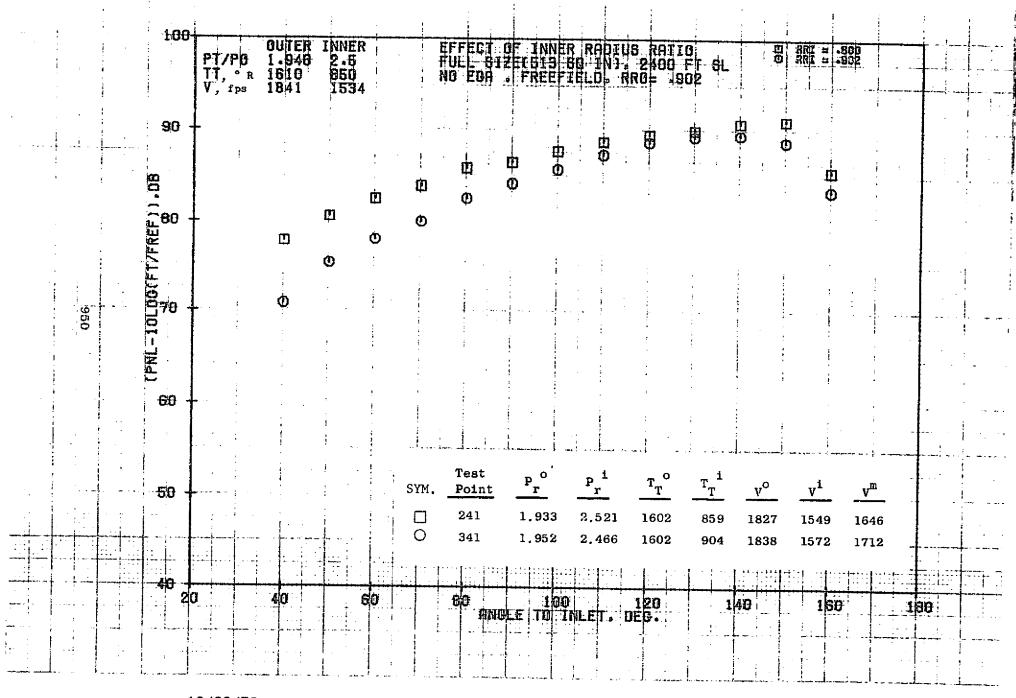


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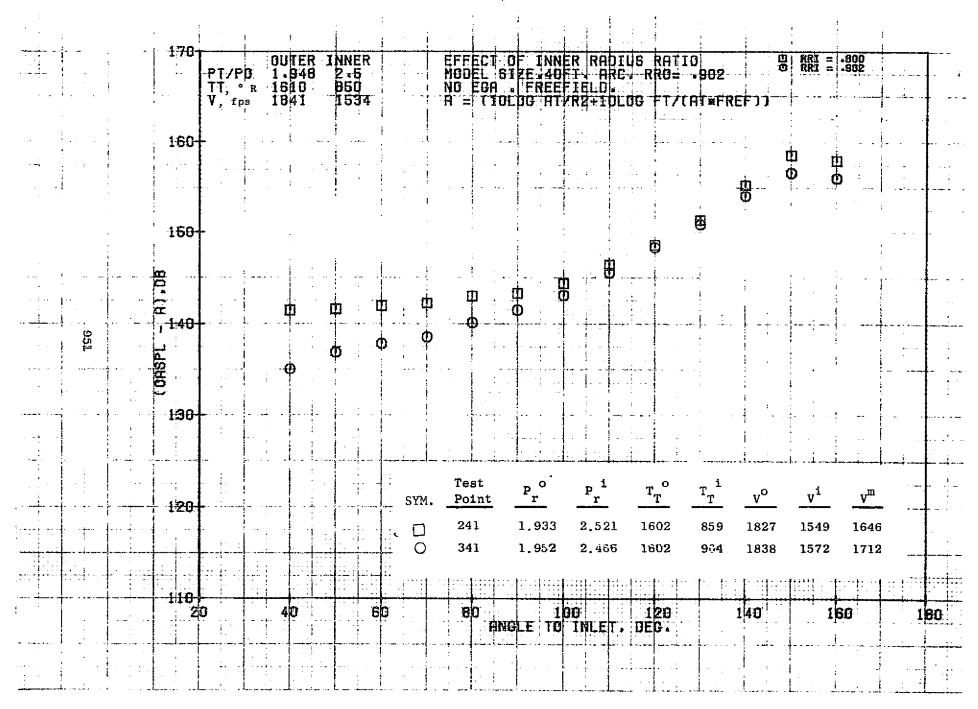


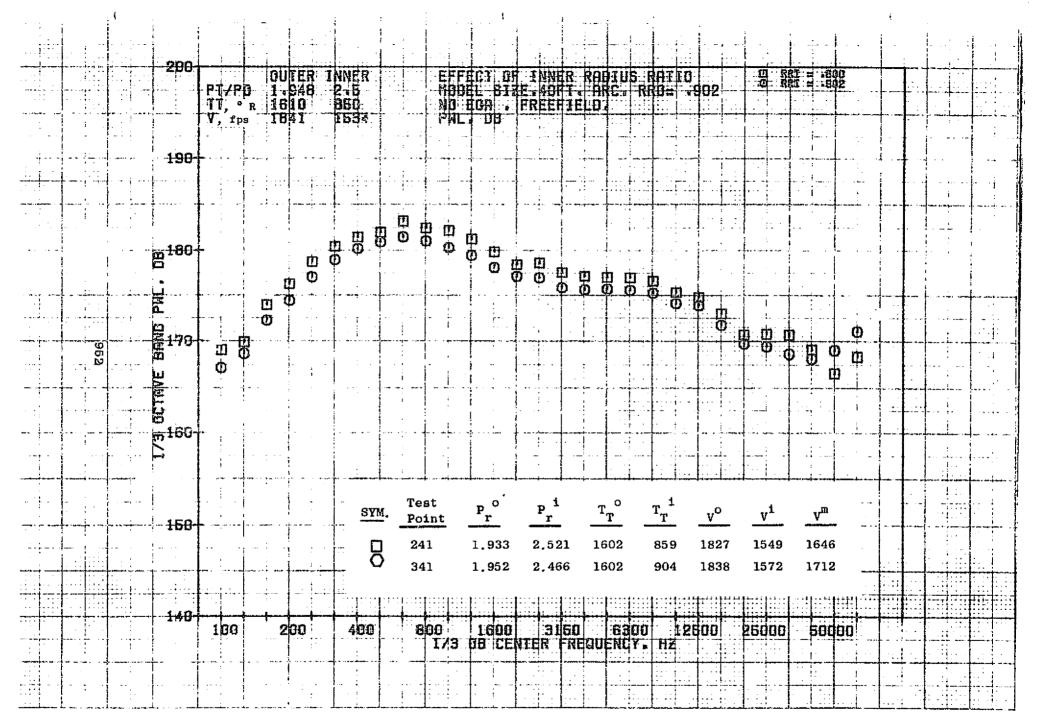




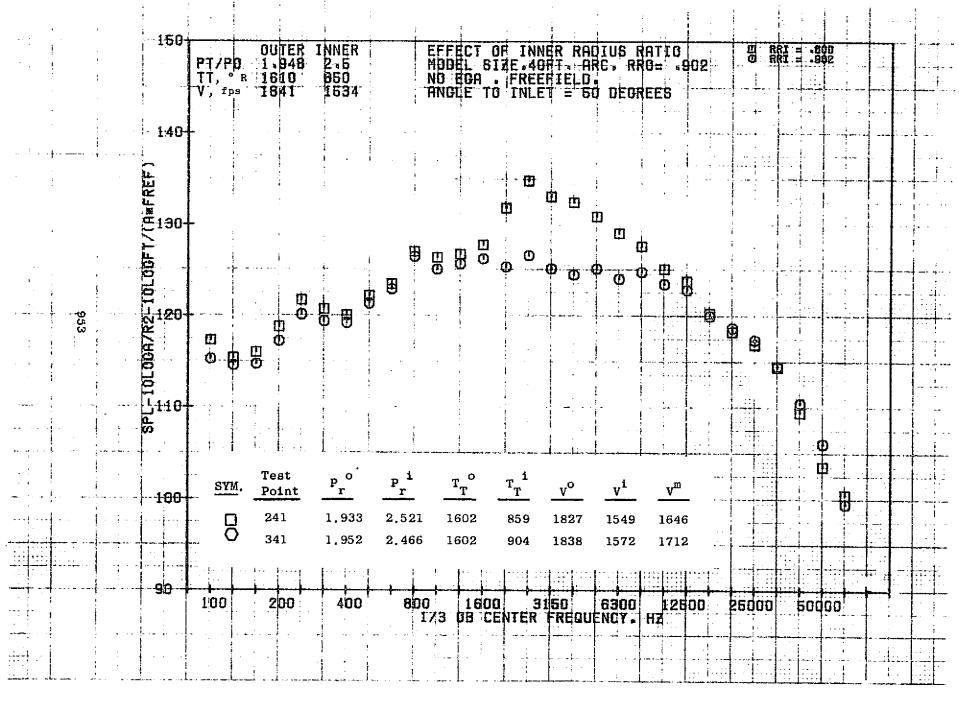
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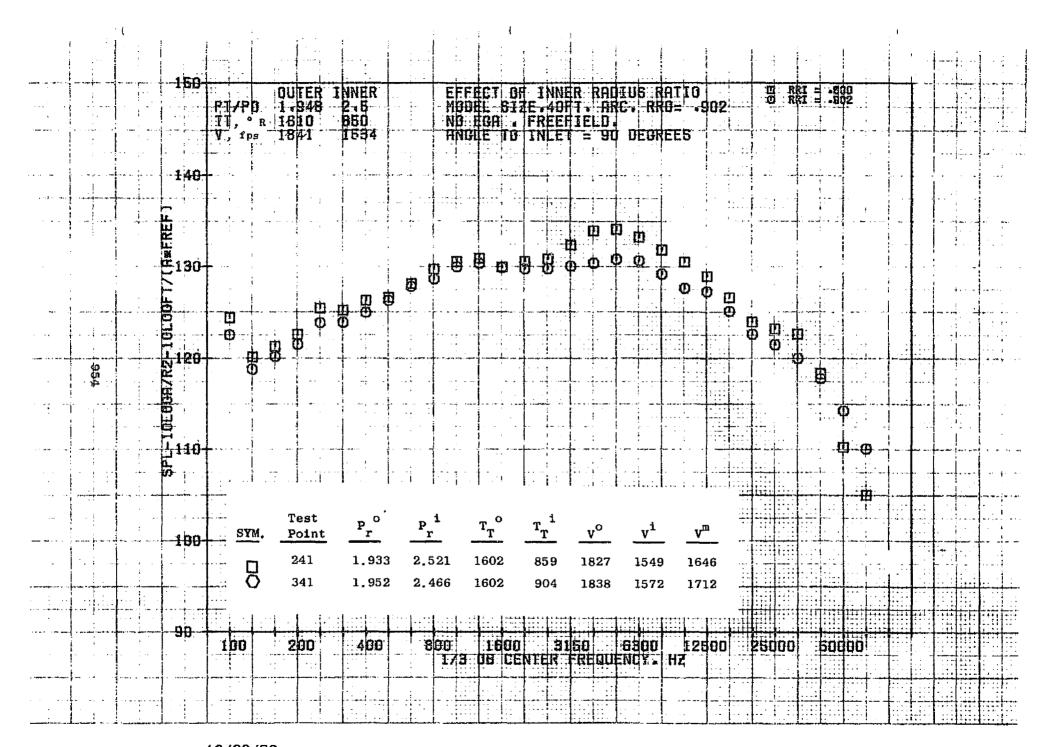
79 BURCH A.

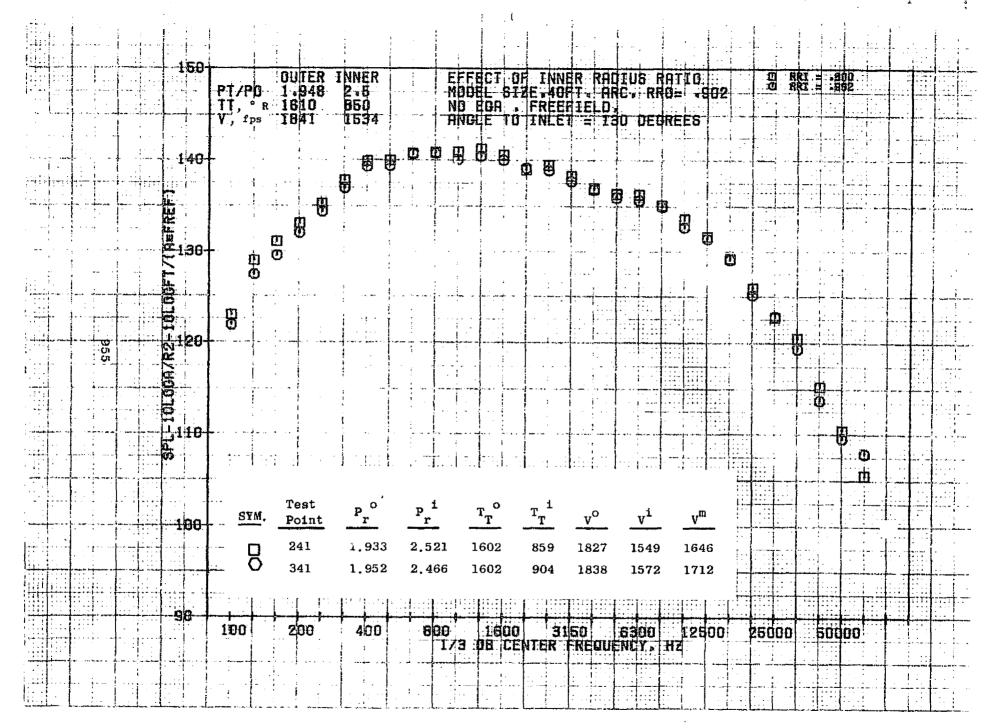


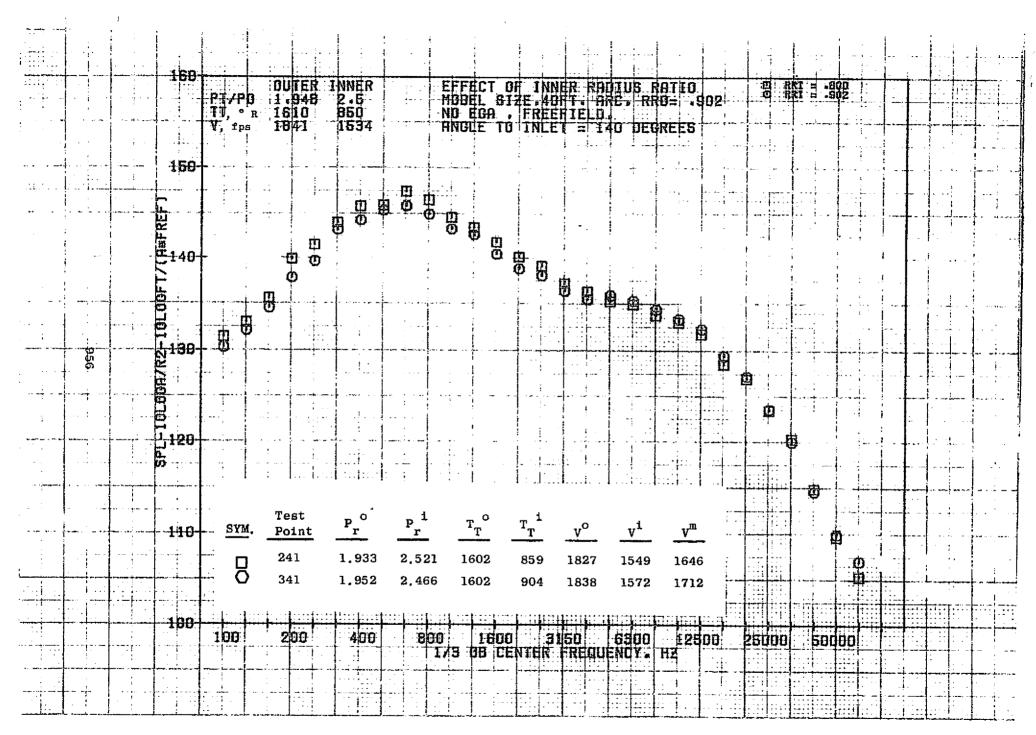


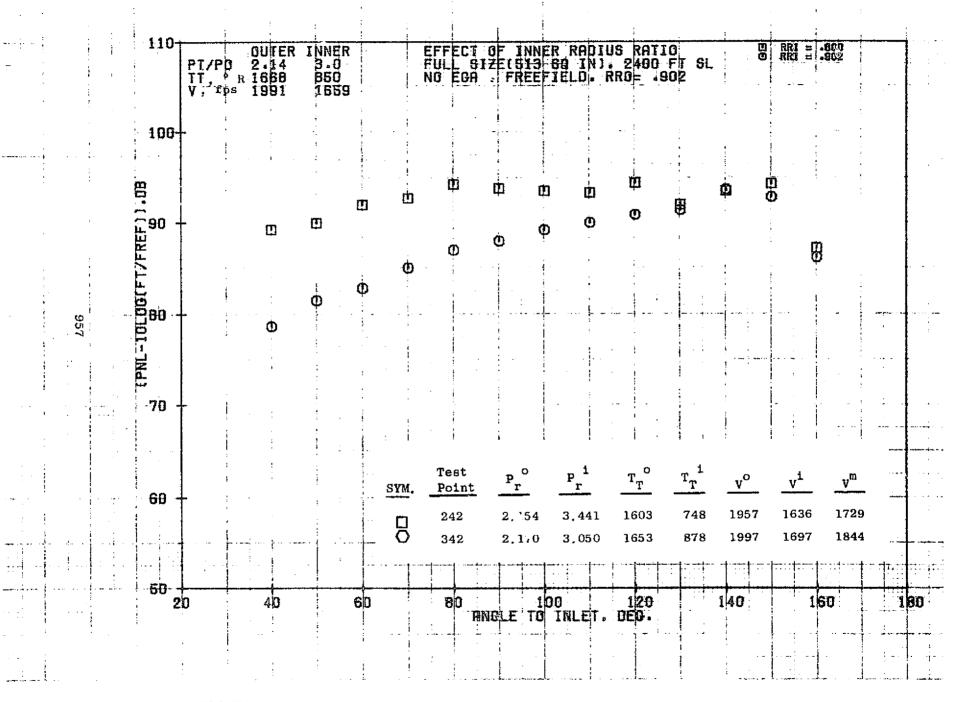
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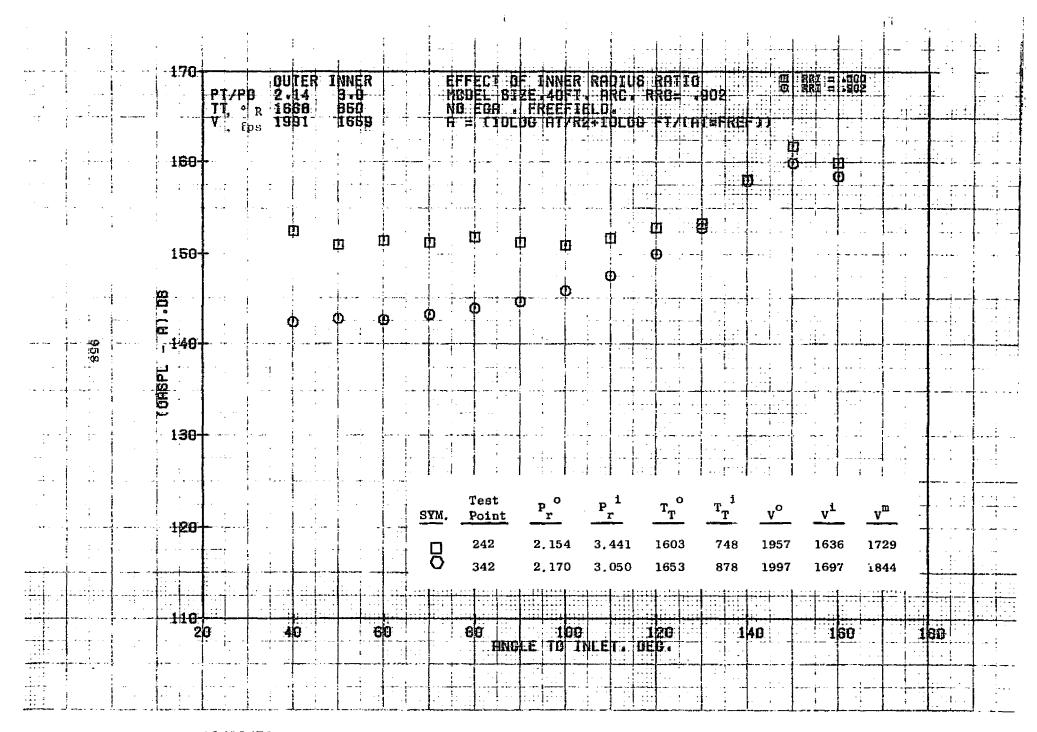


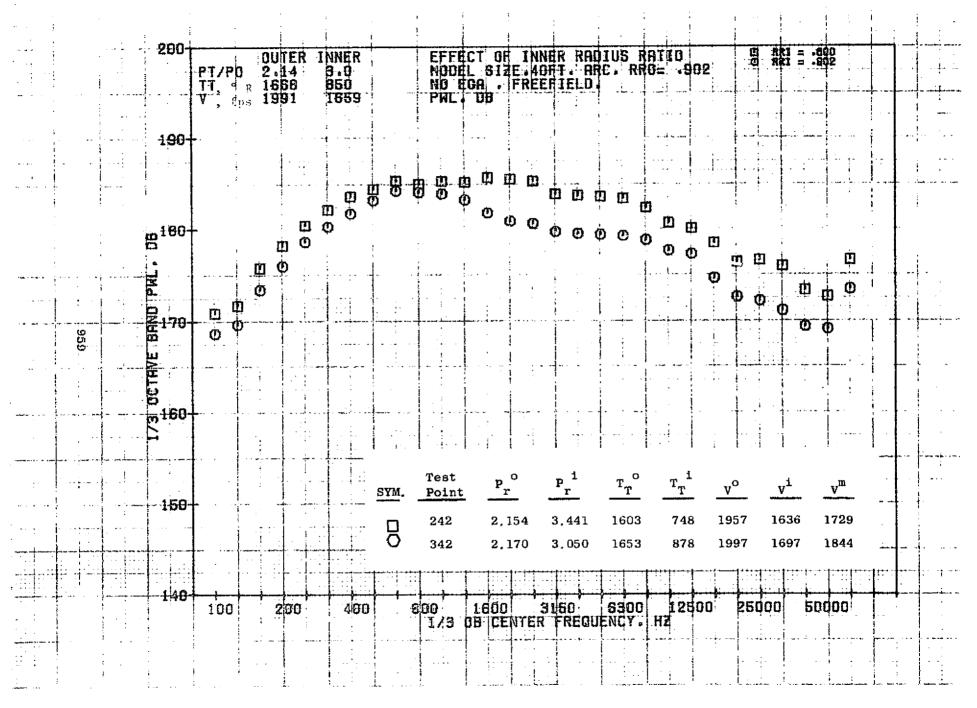


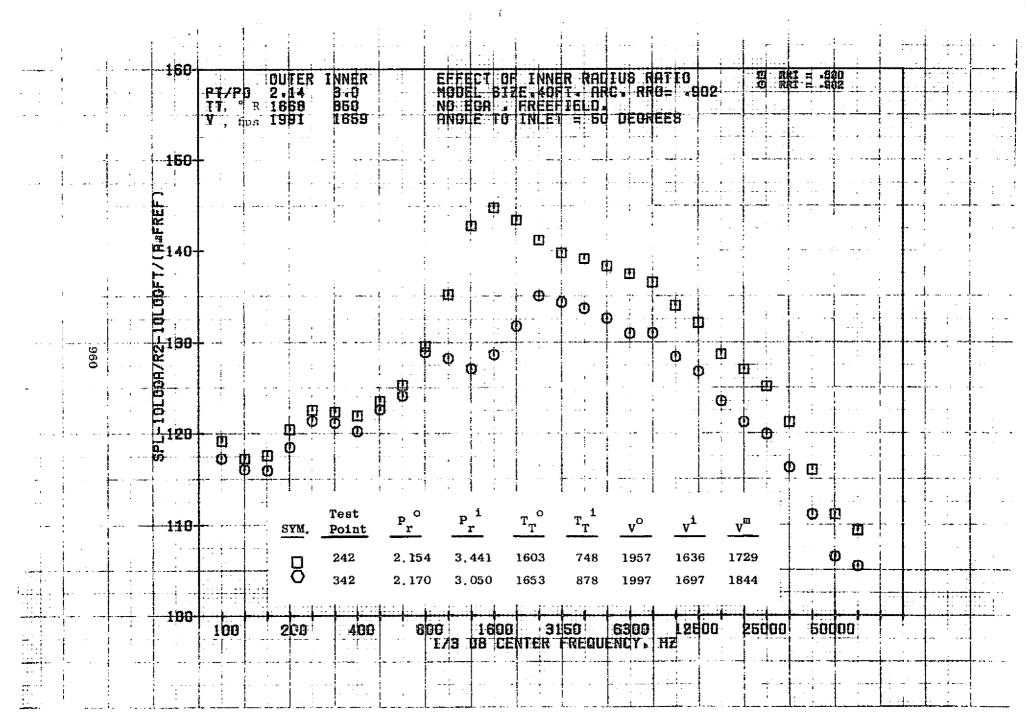


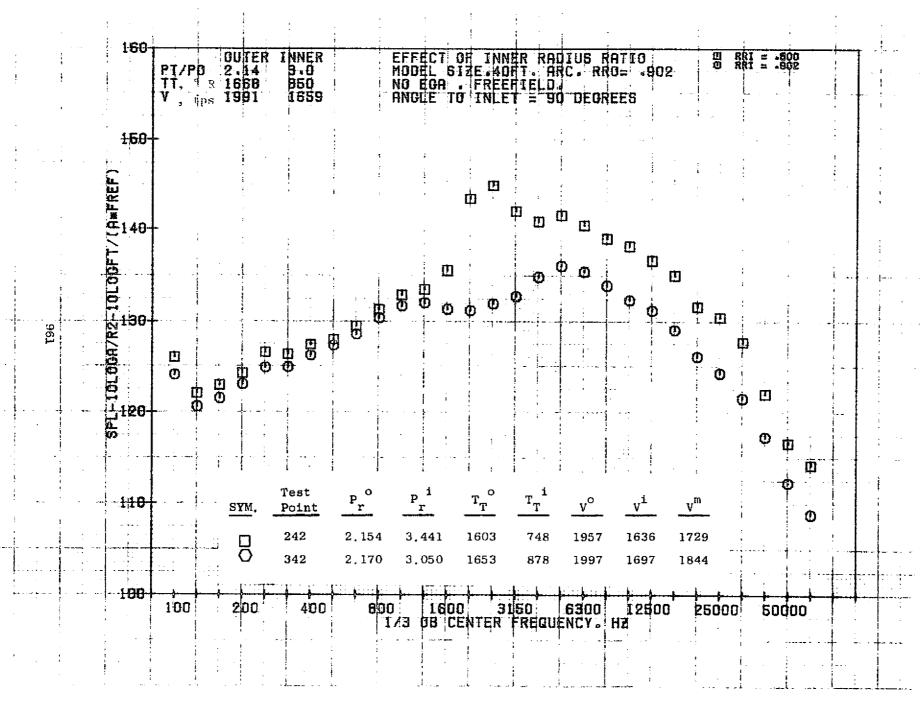


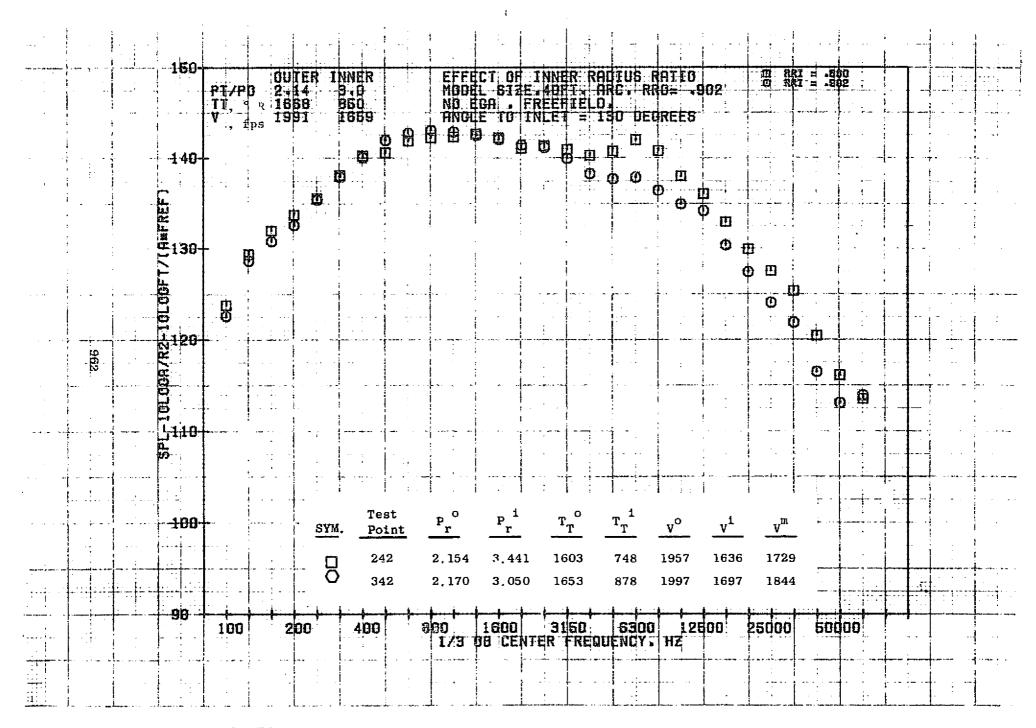


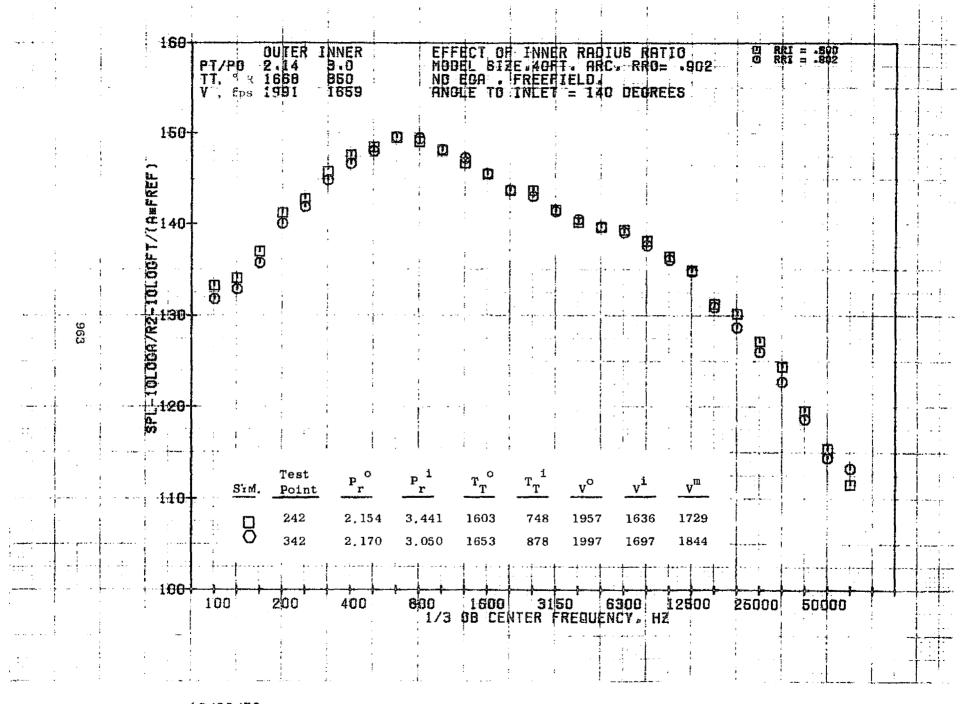




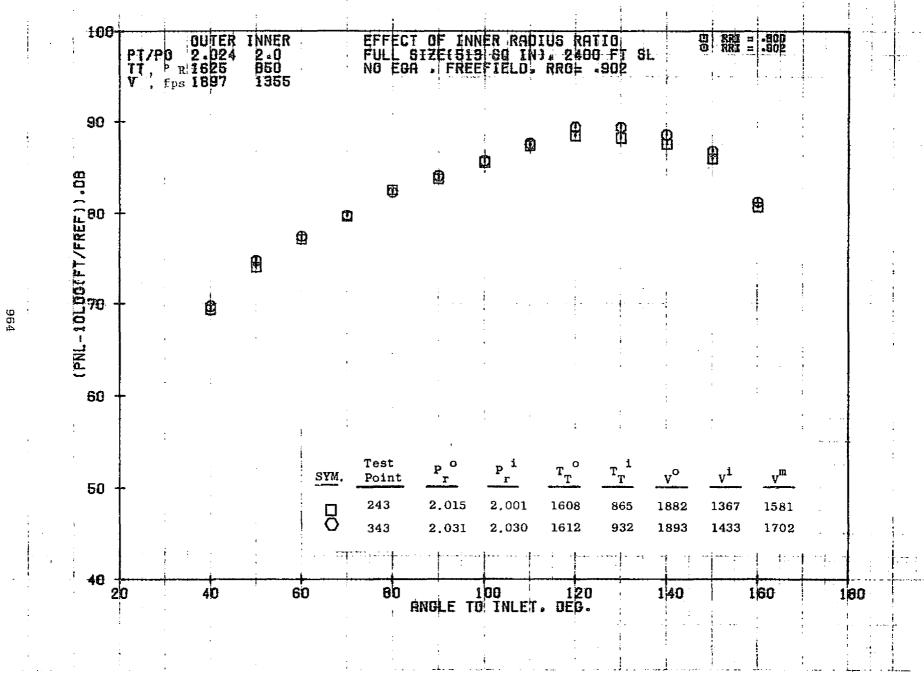








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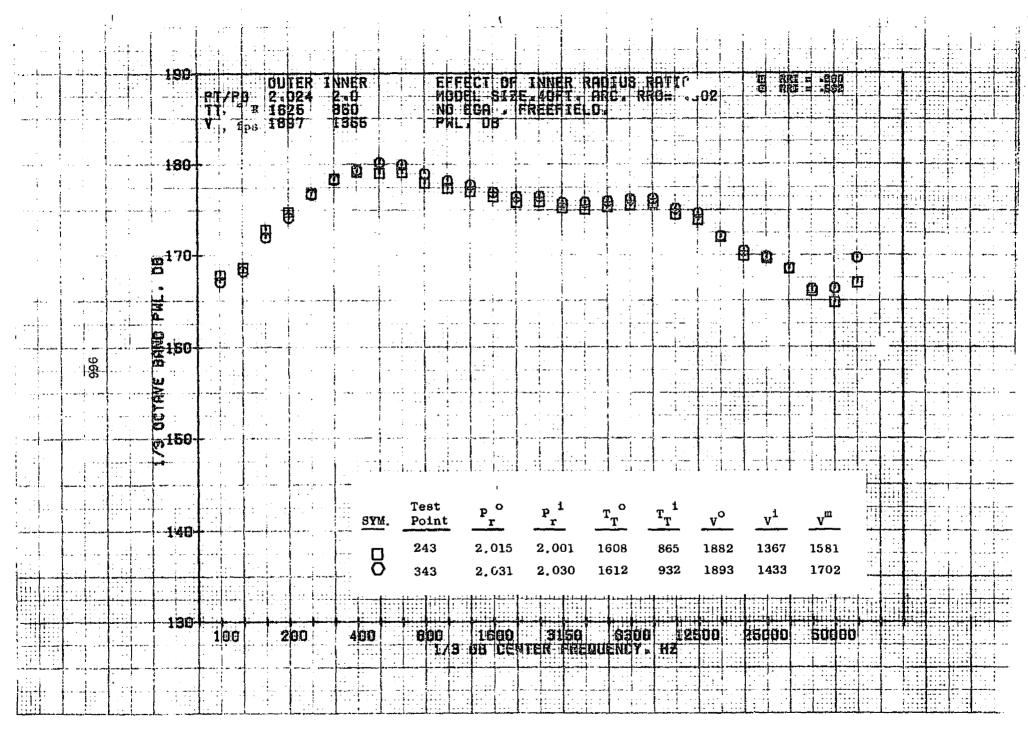


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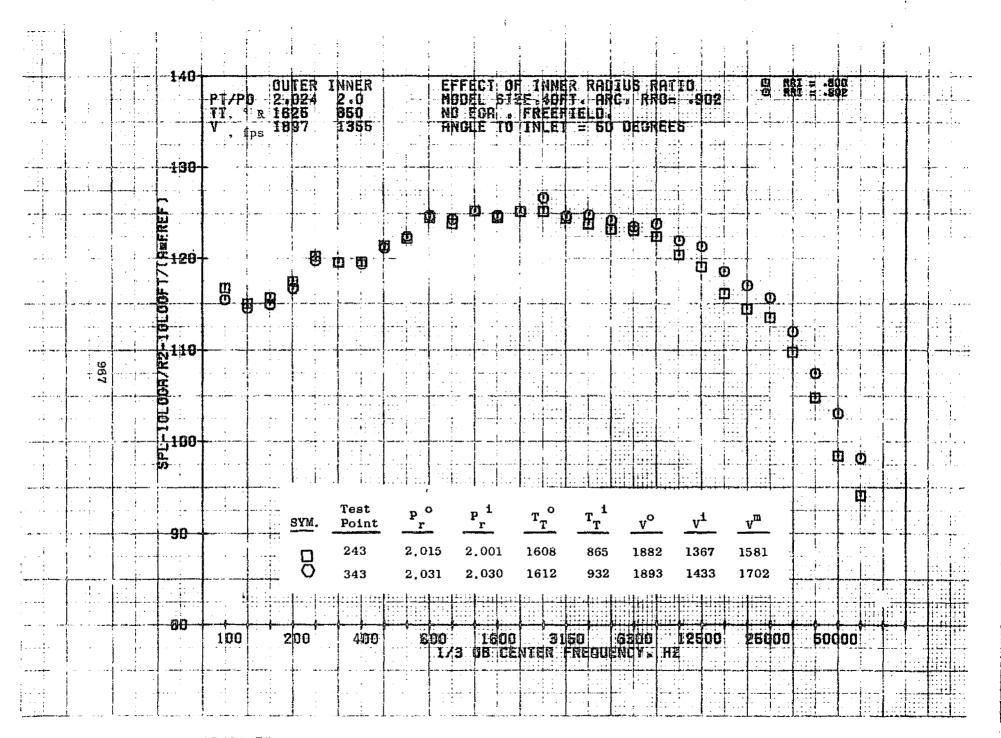
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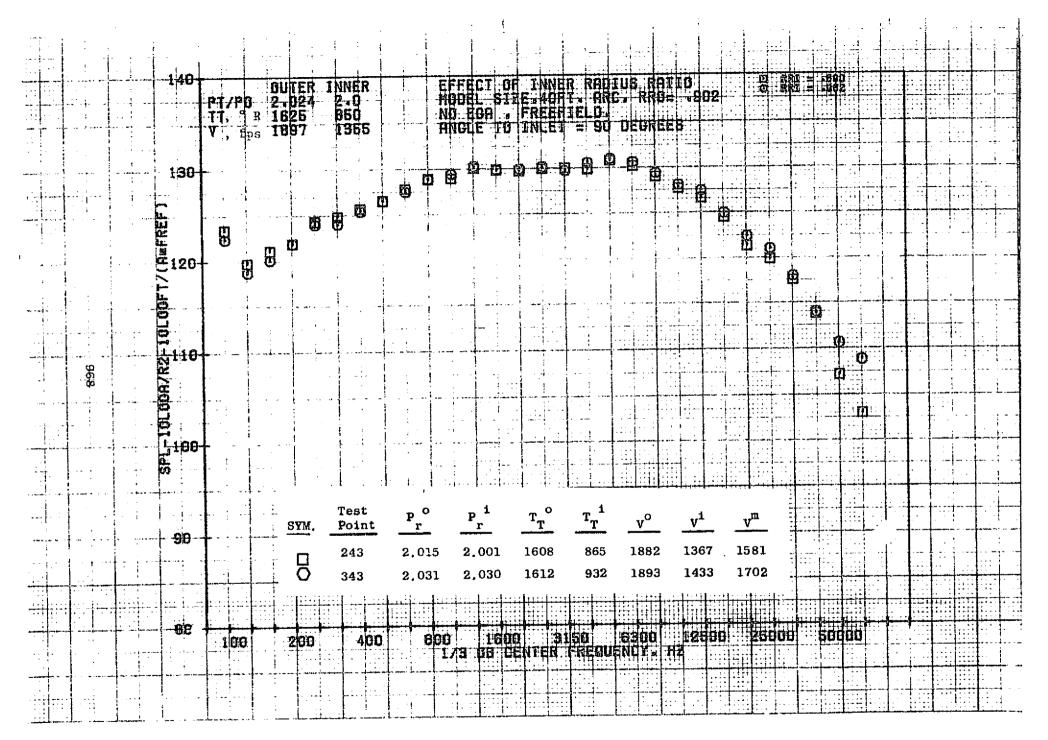
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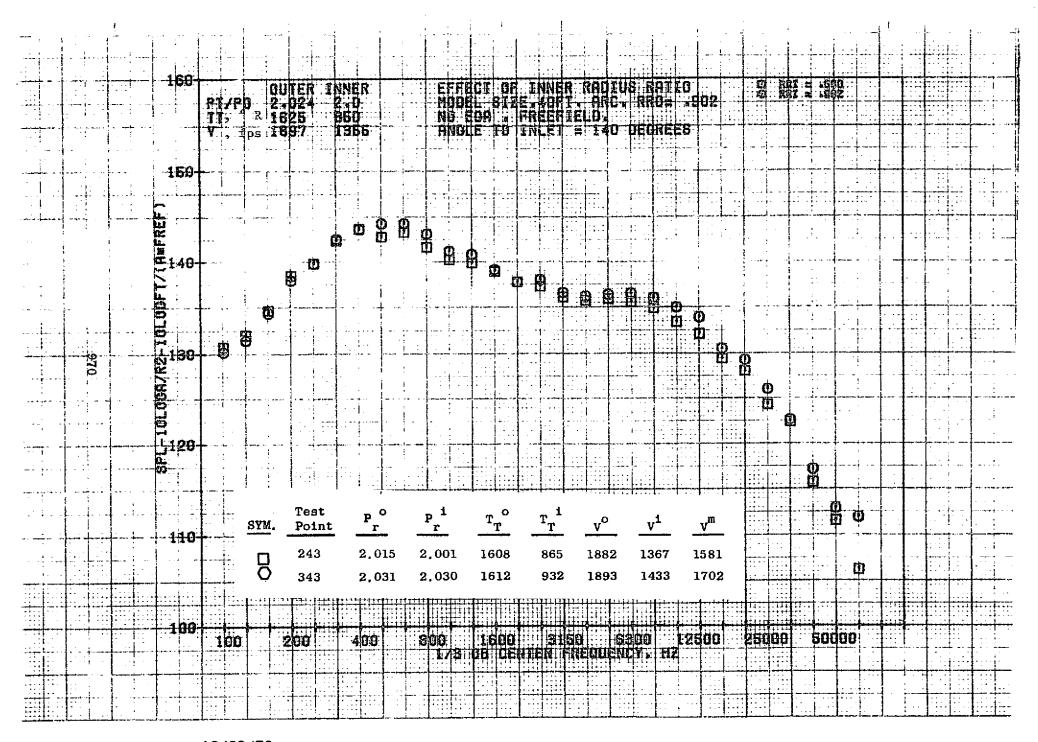
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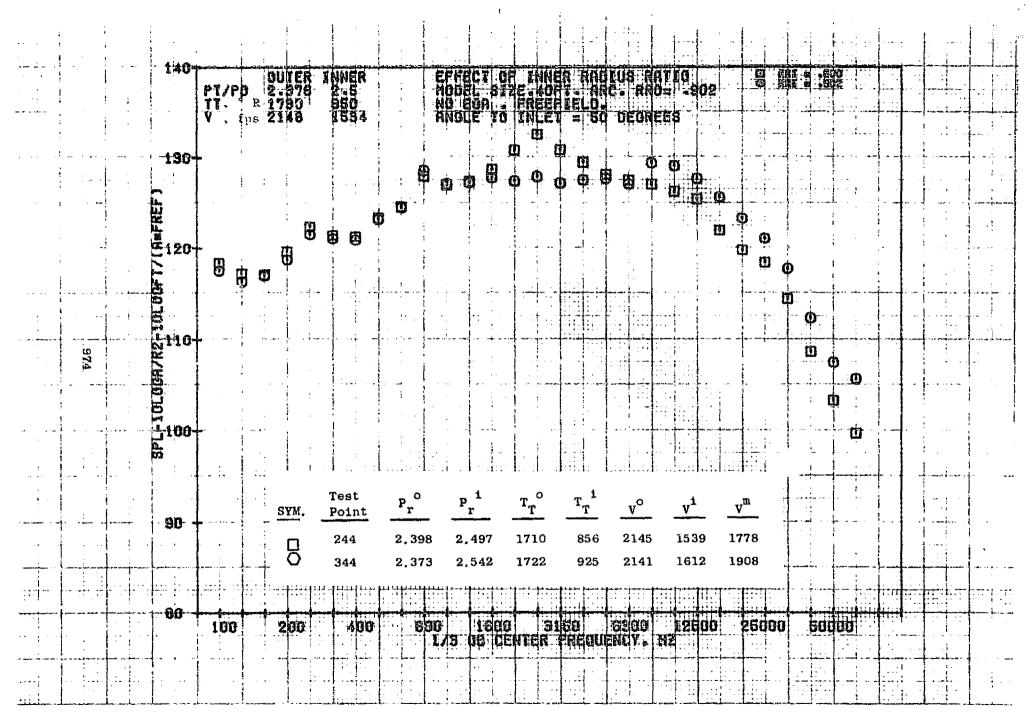
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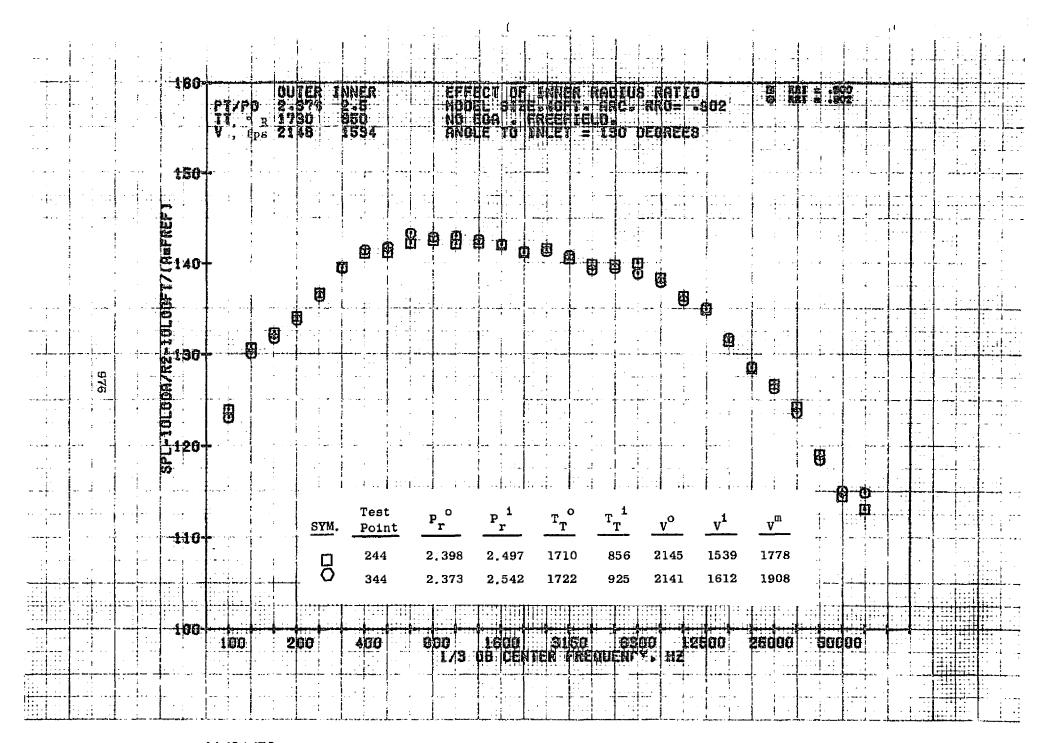


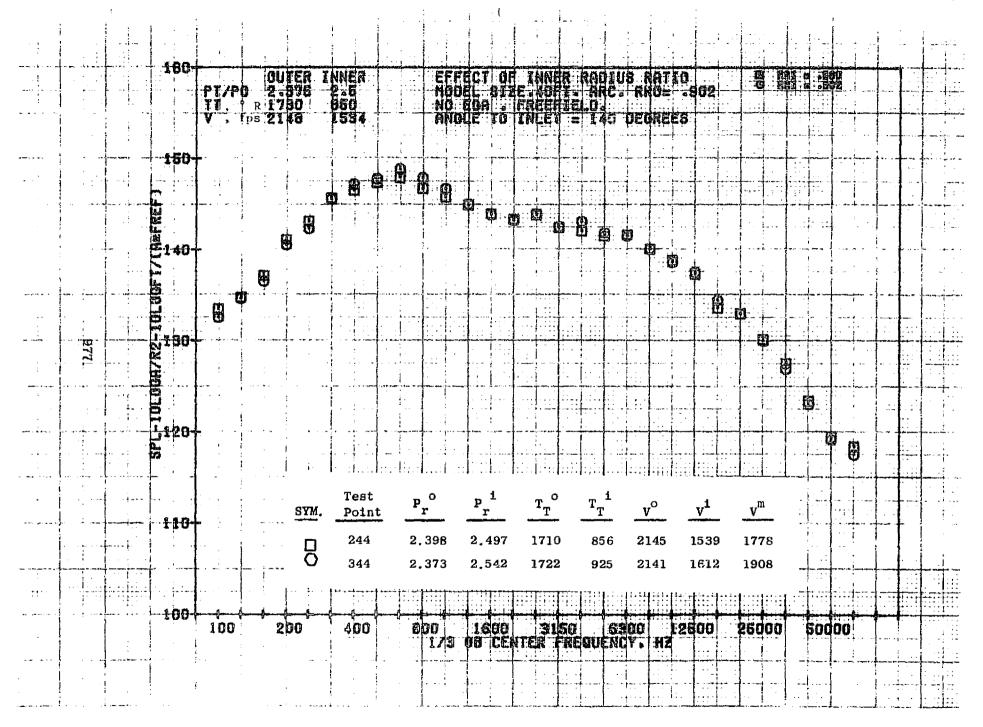
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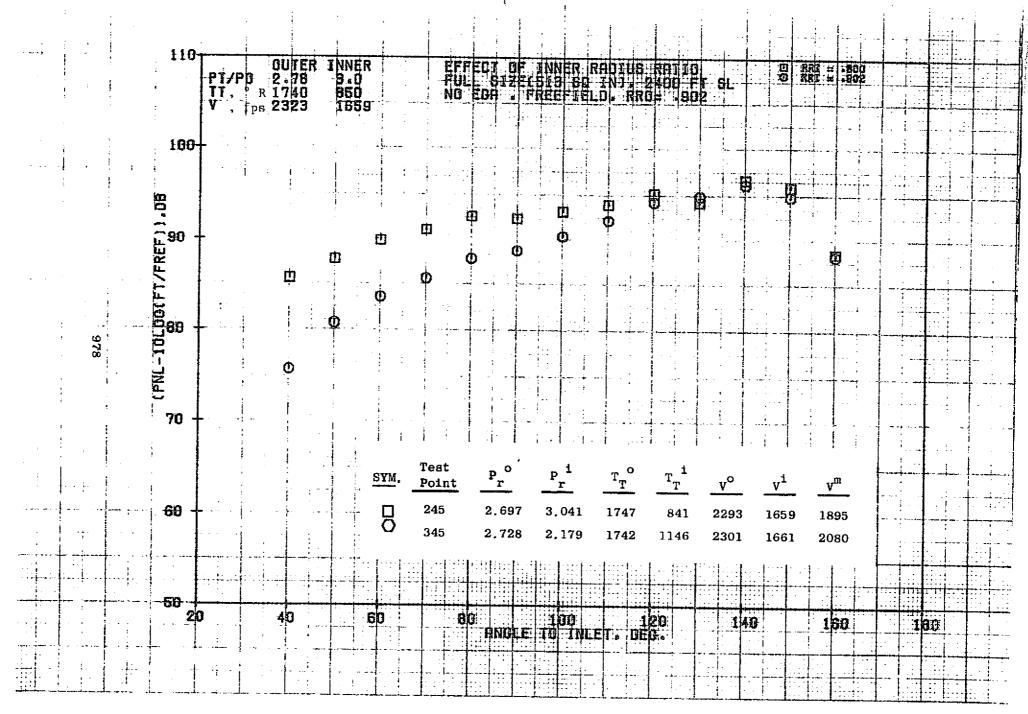
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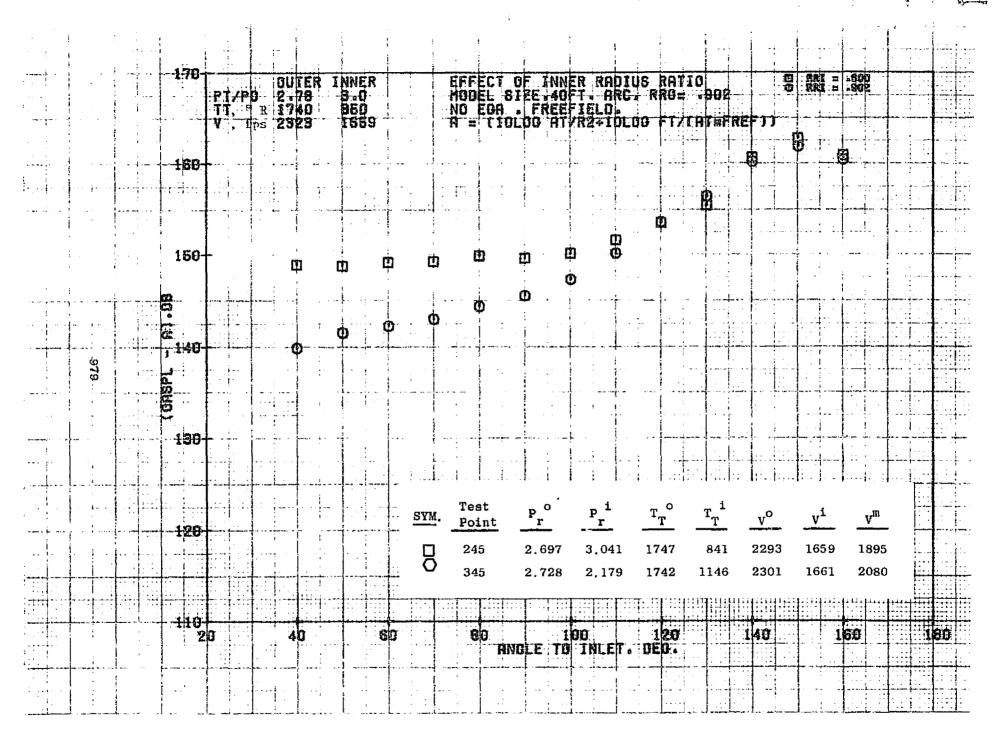
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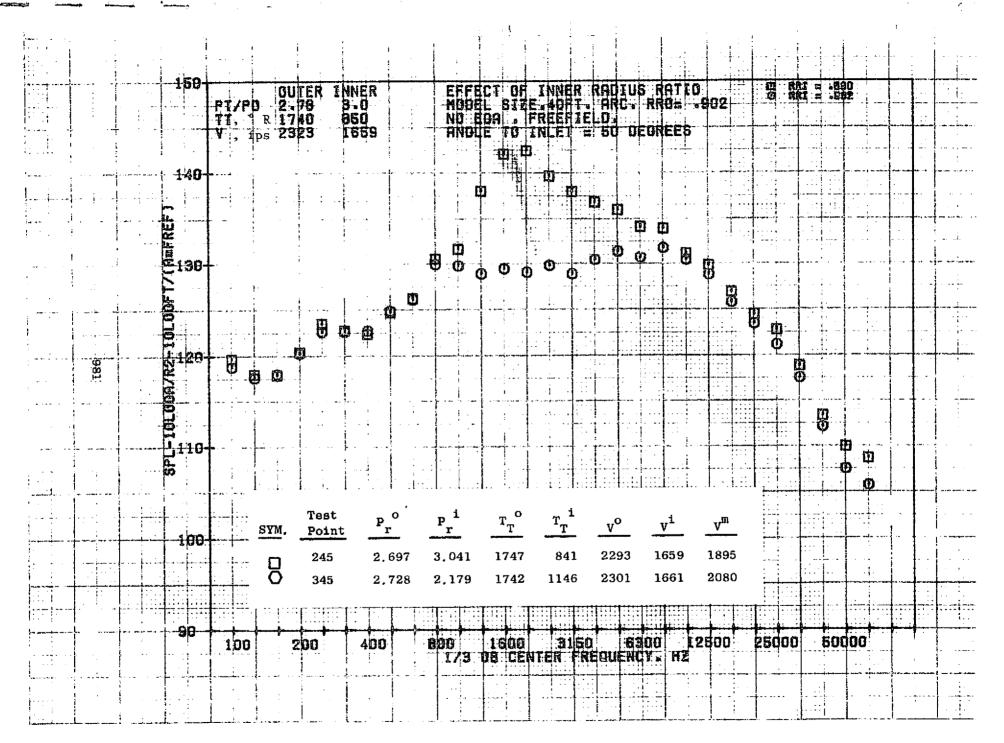




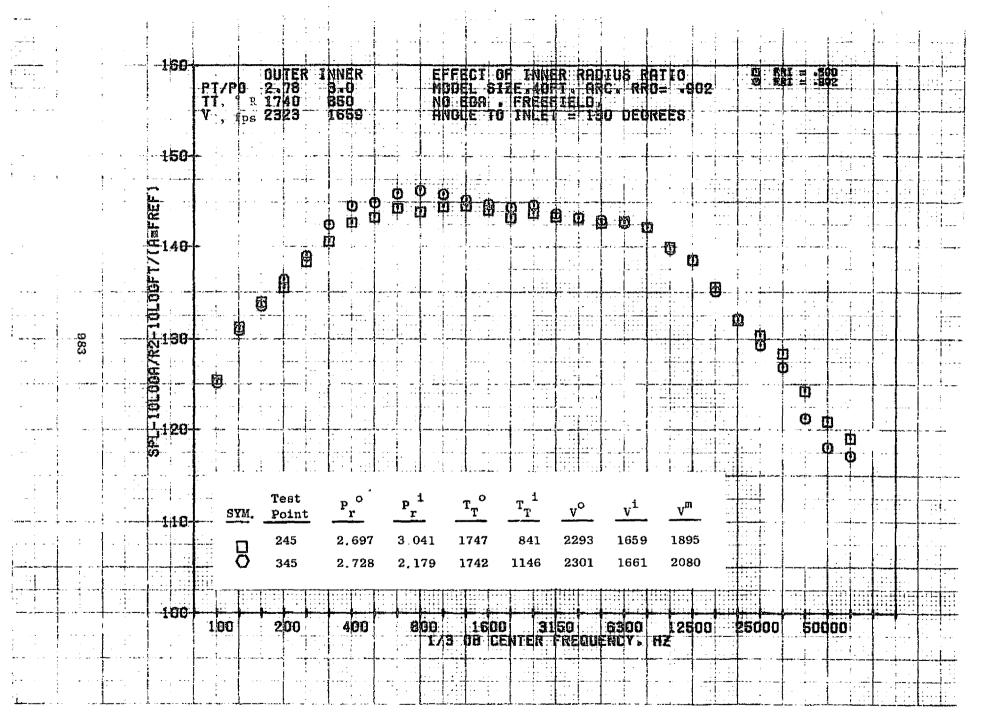


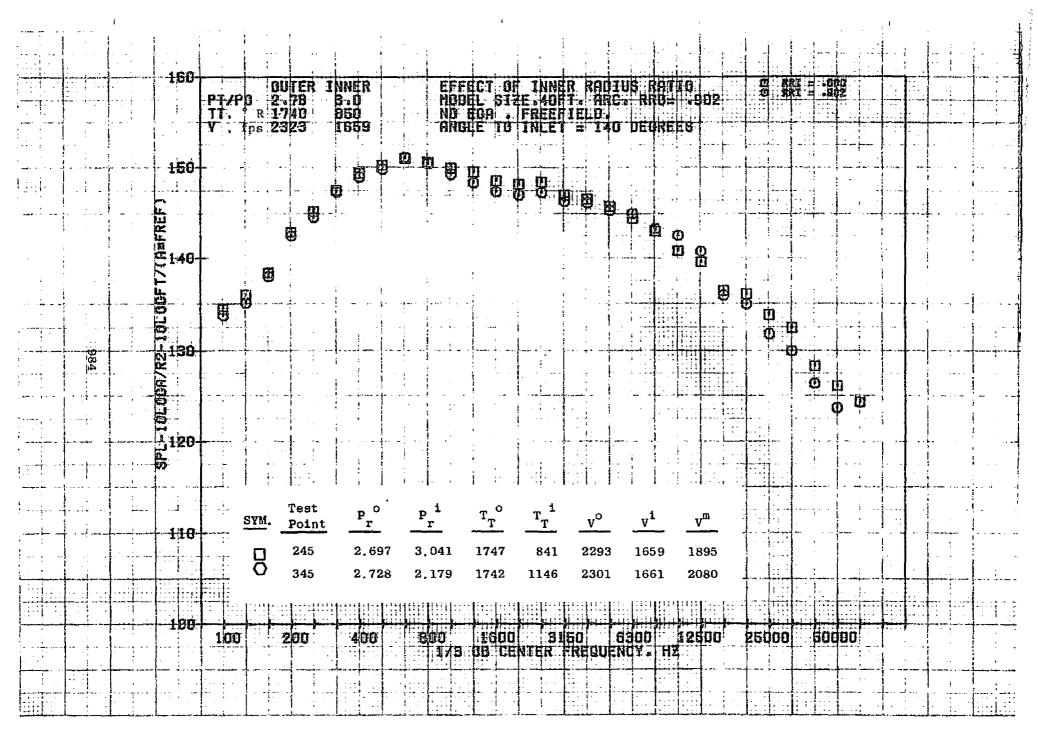
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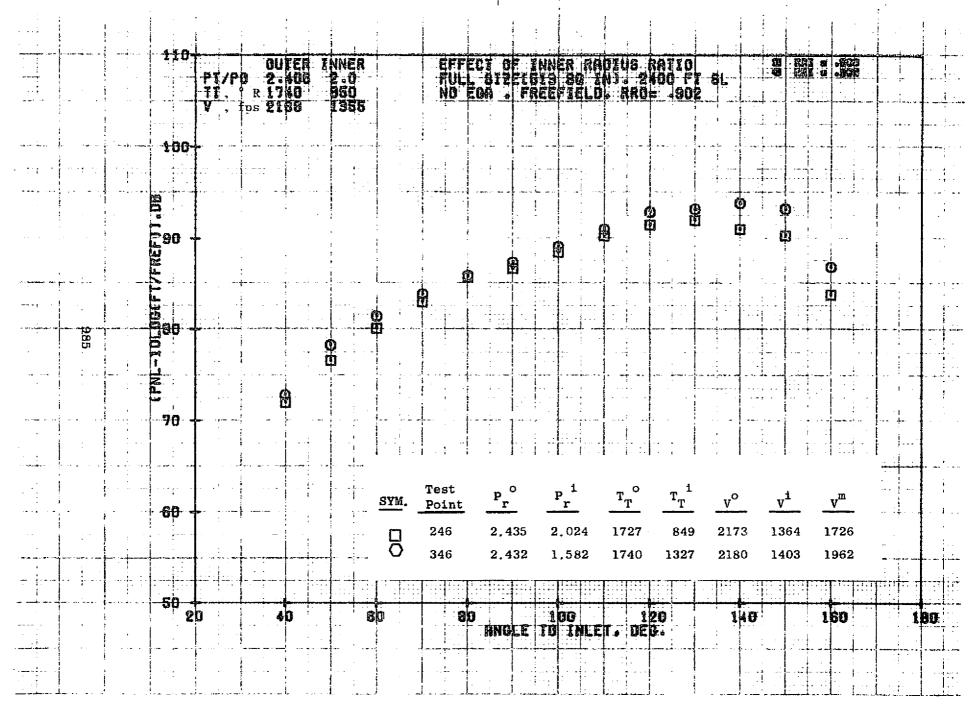
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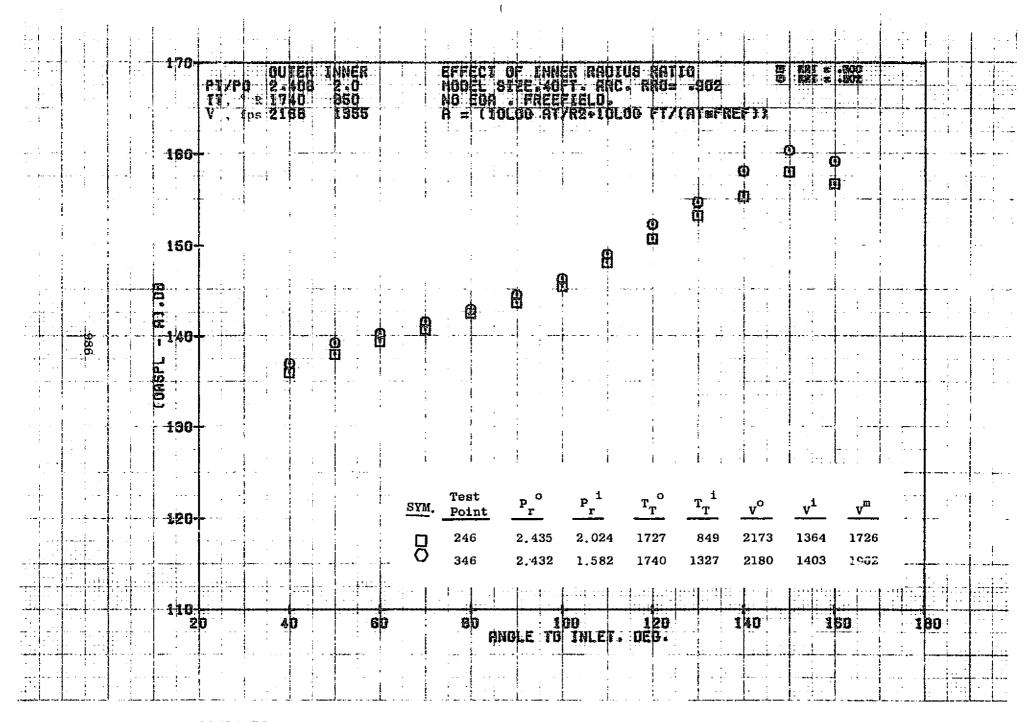
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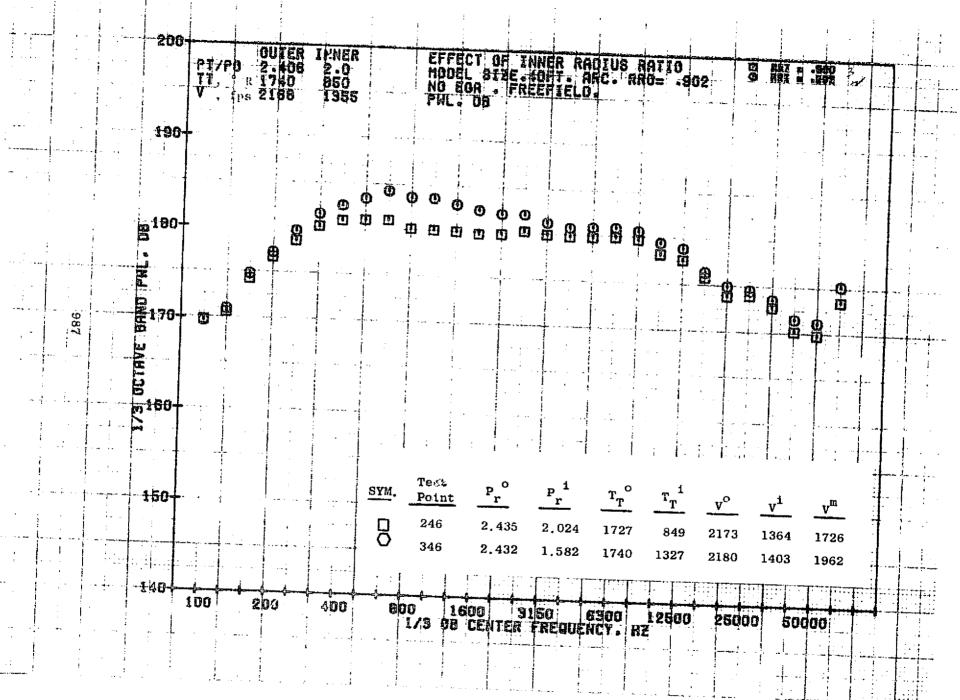




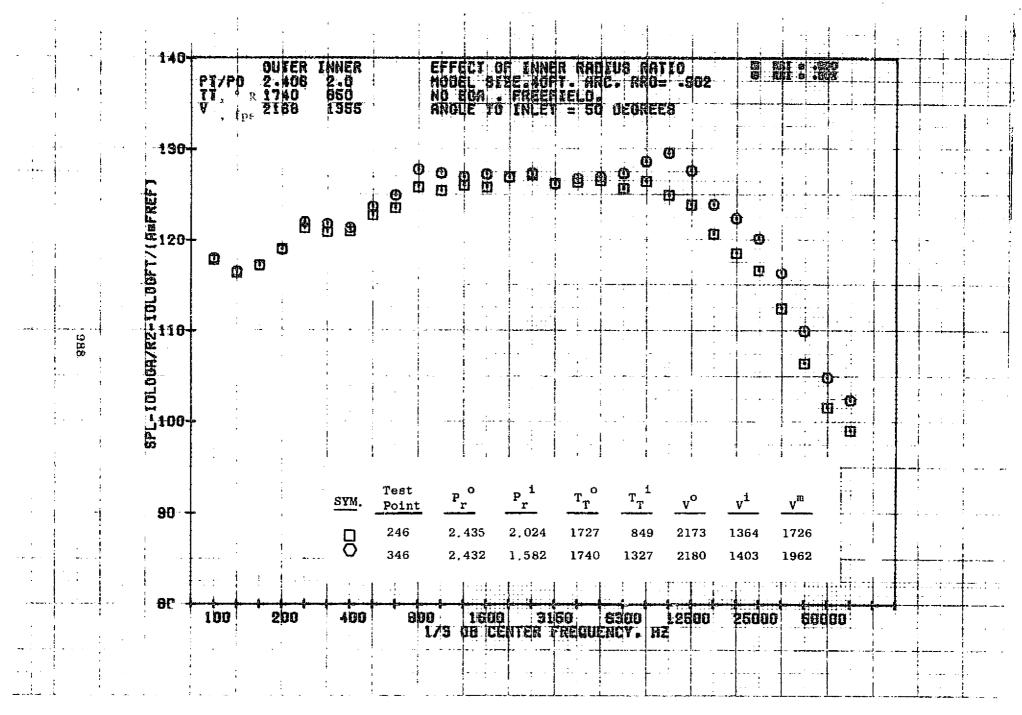


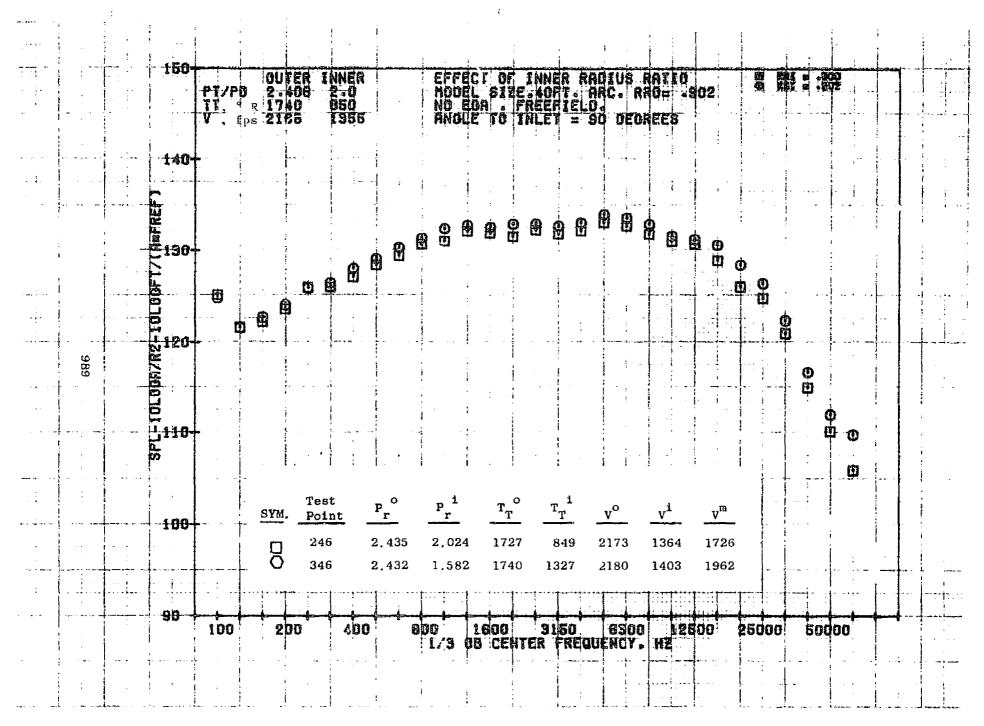
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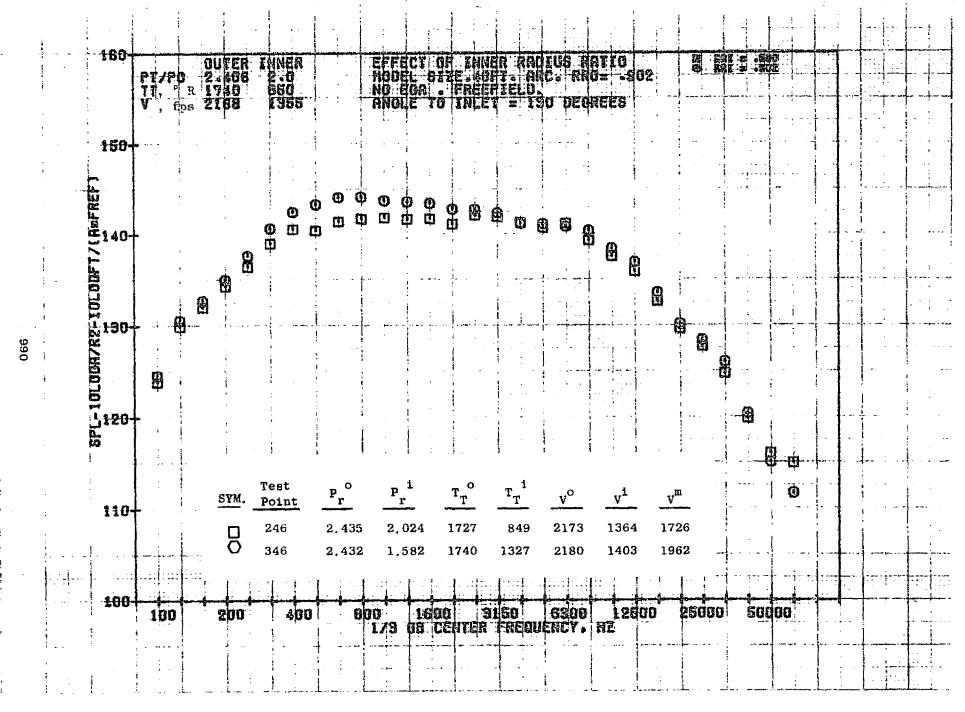


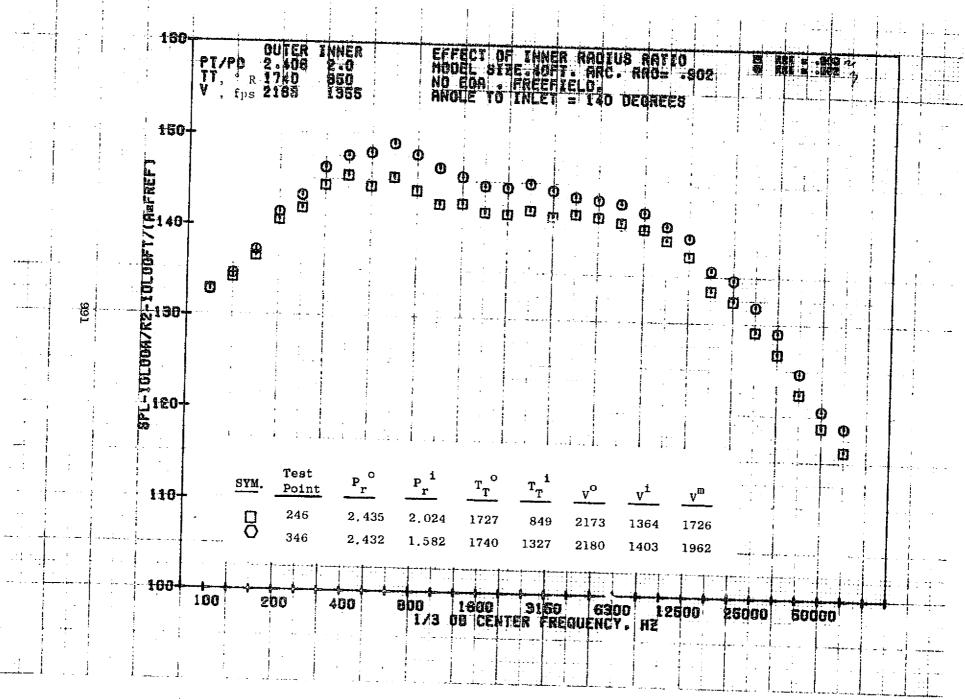


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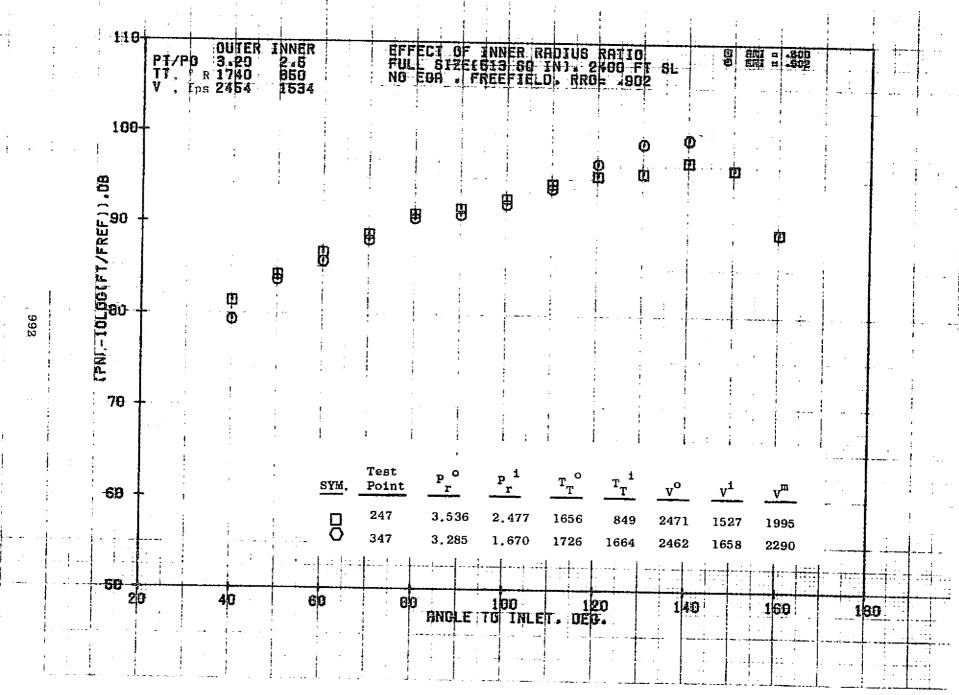




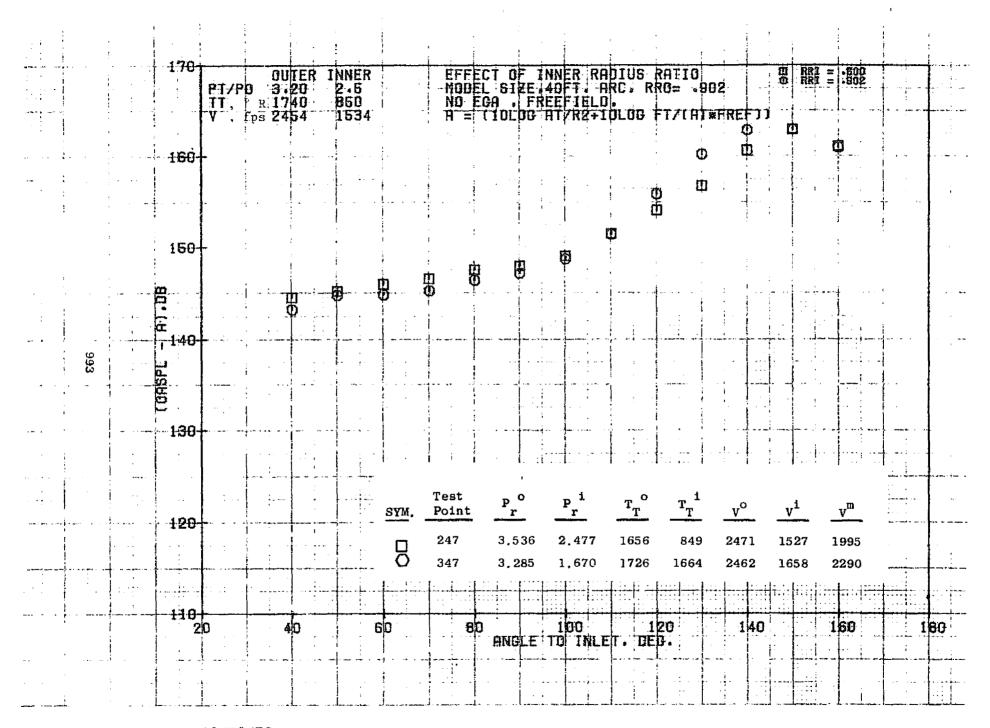


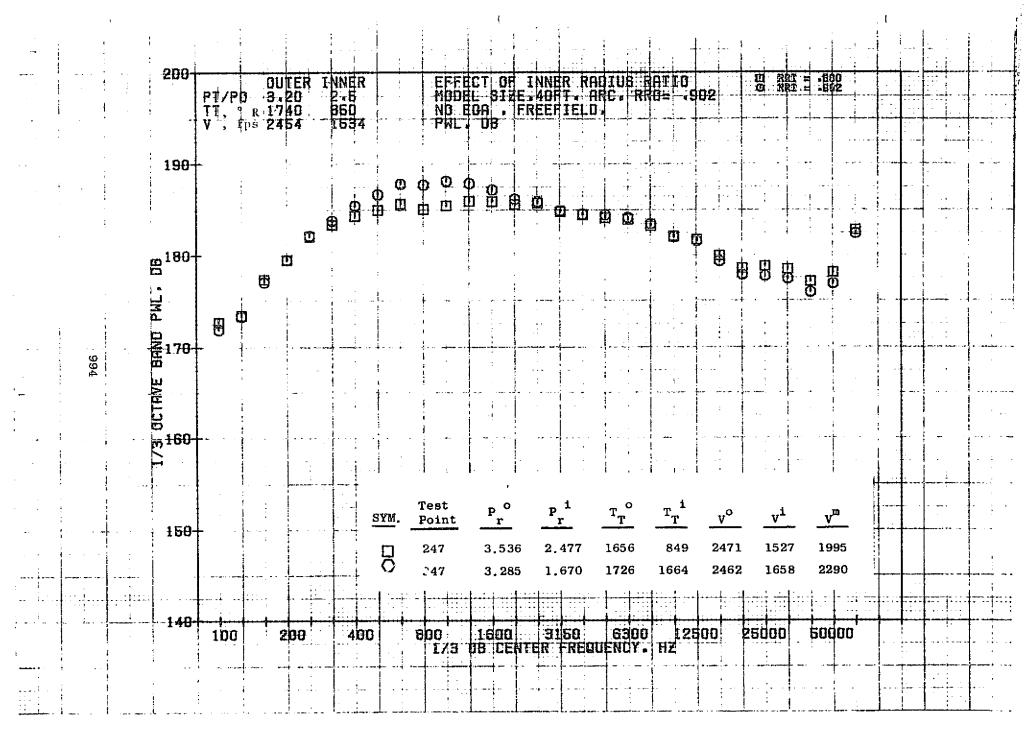


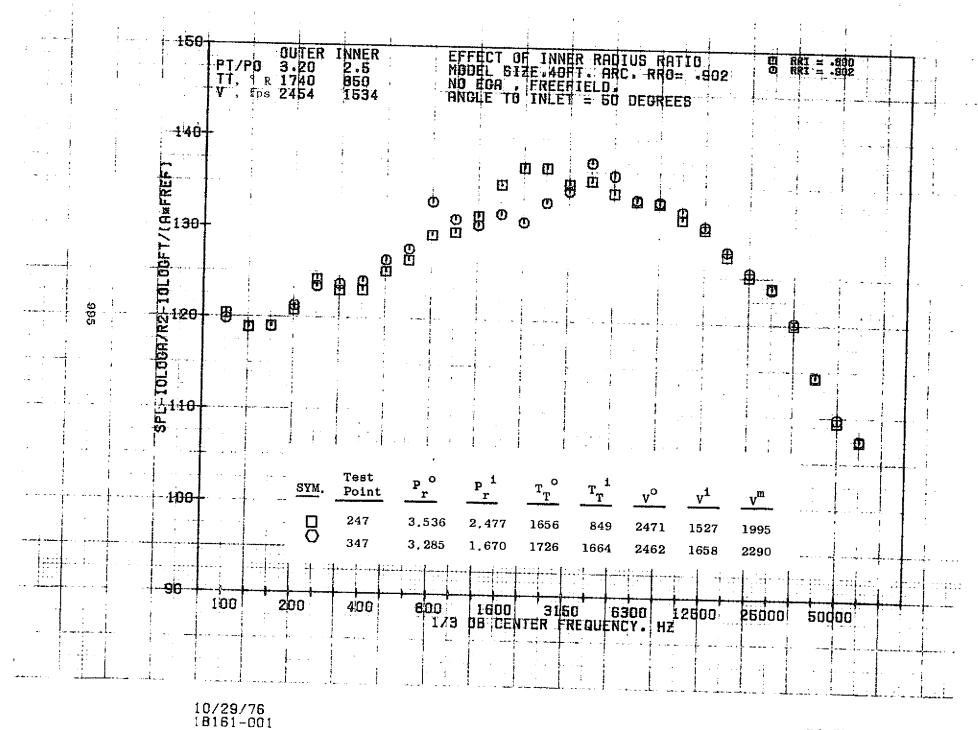
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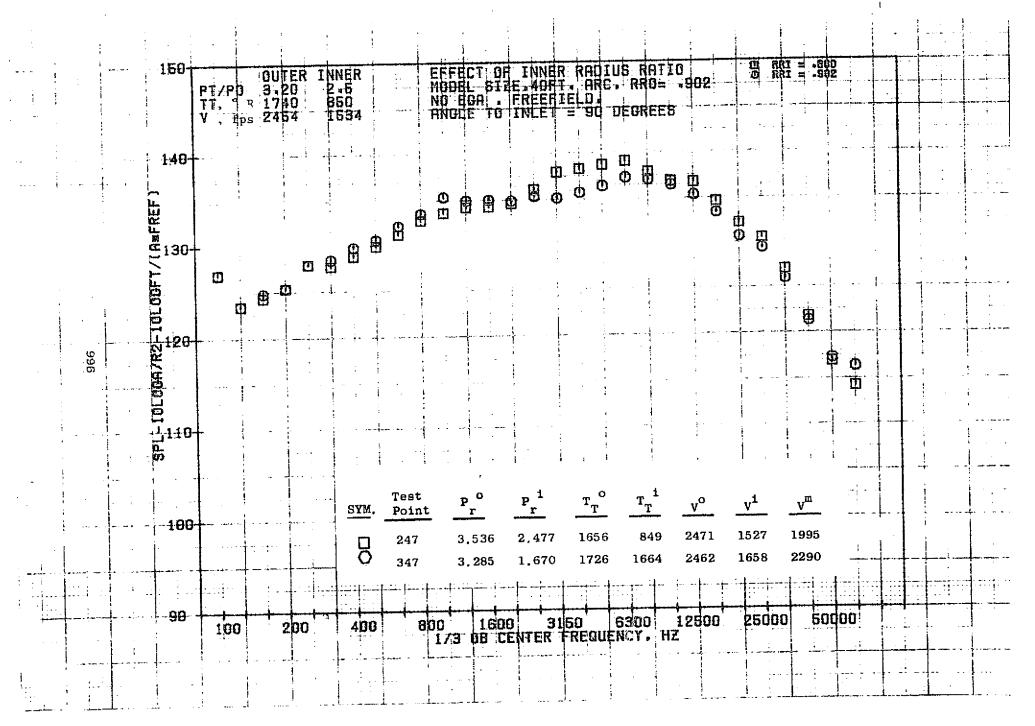


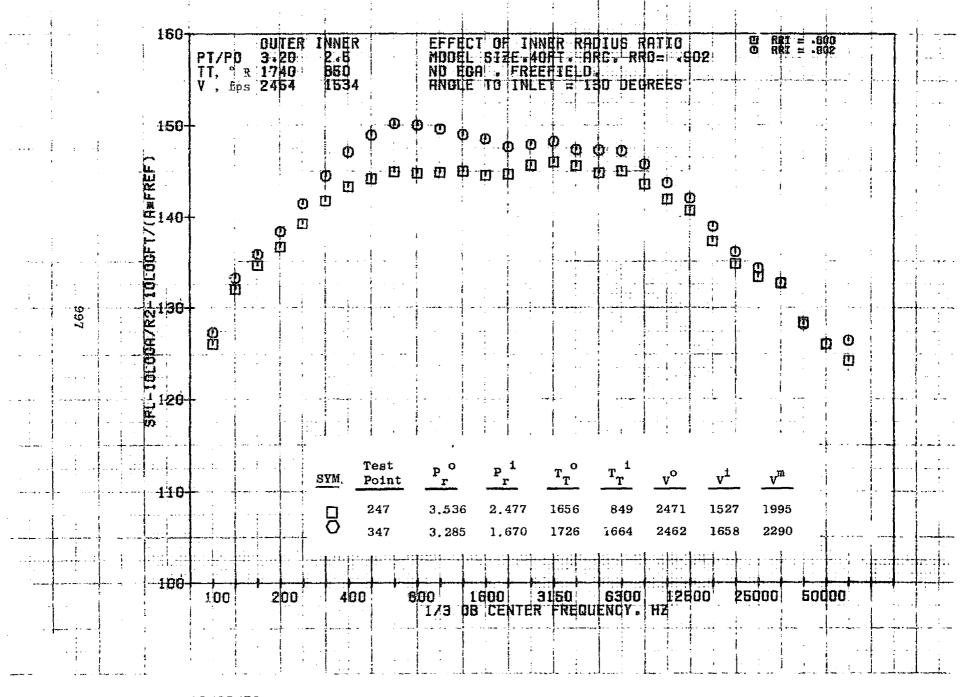
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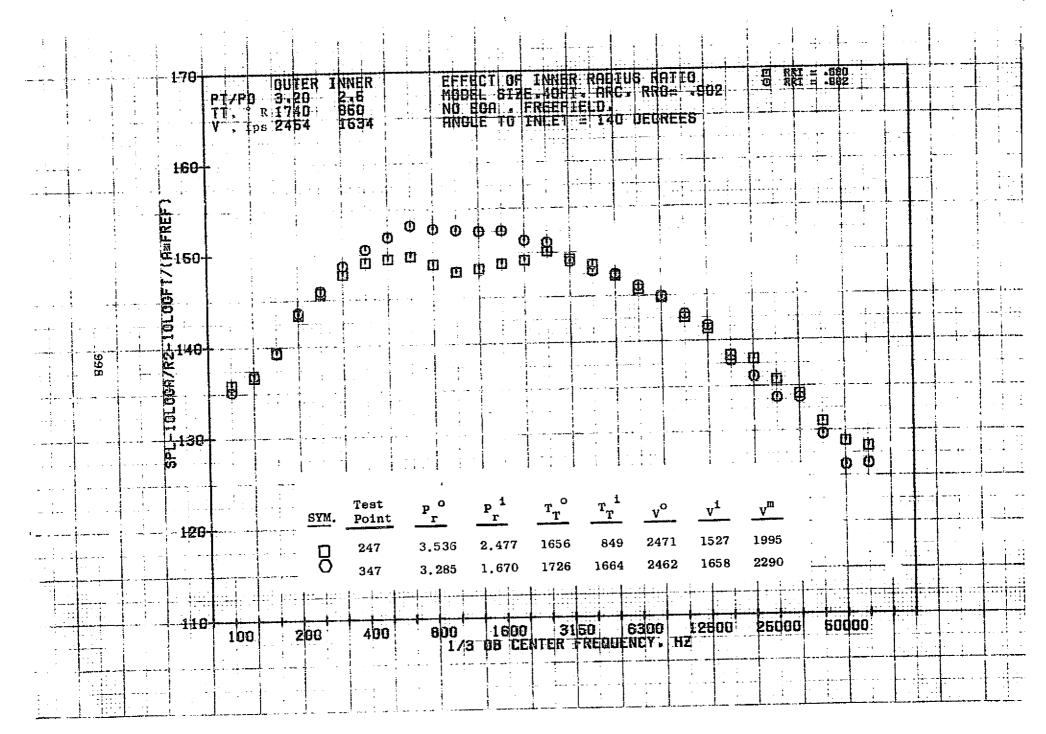


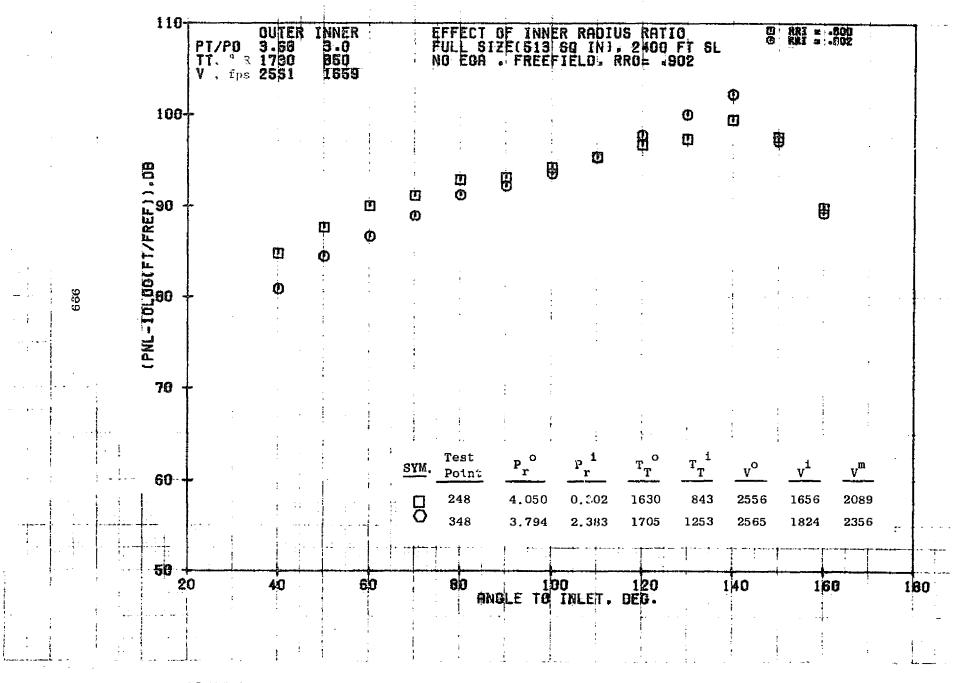




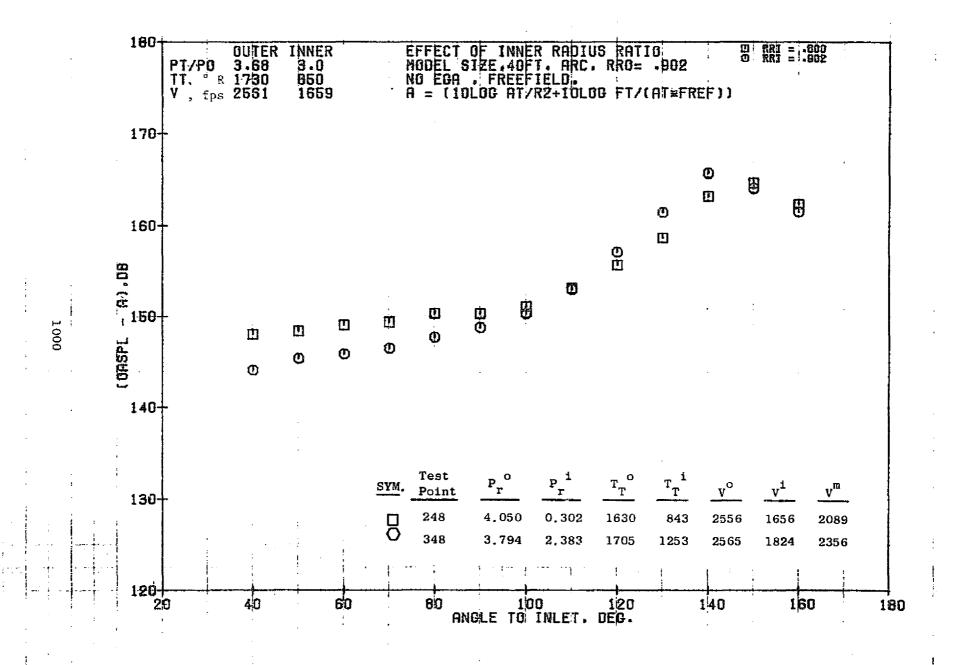


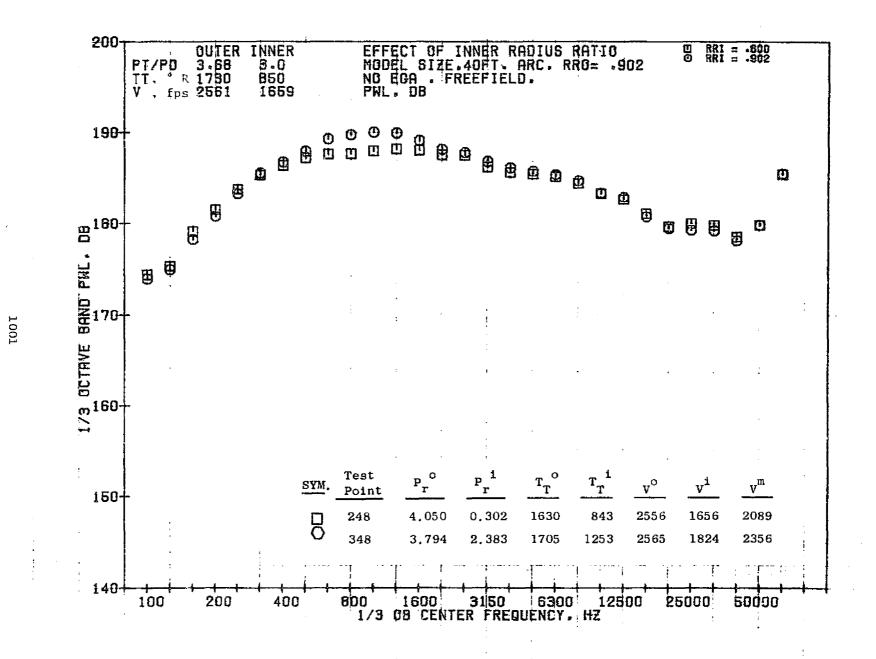


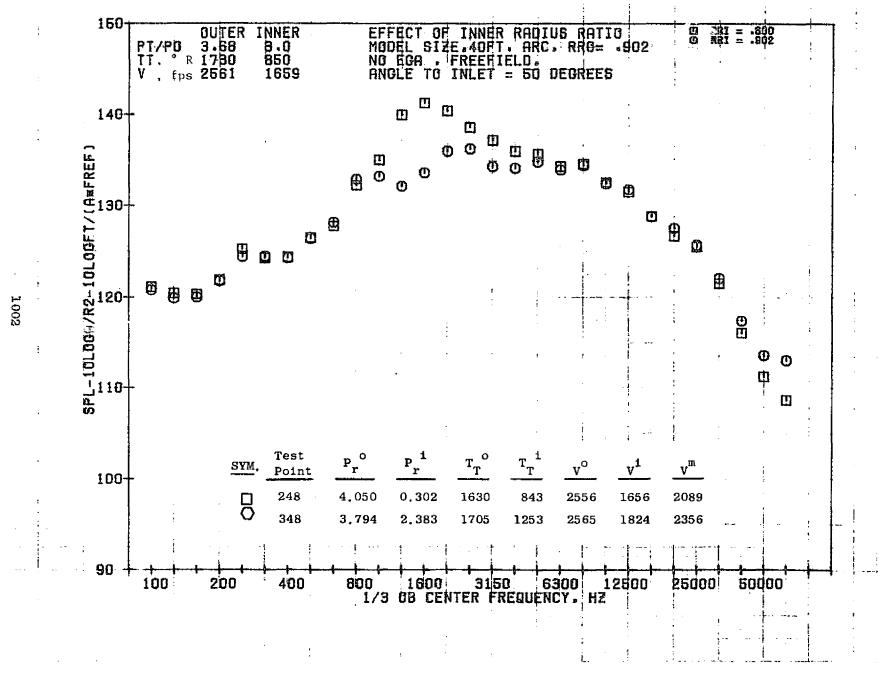




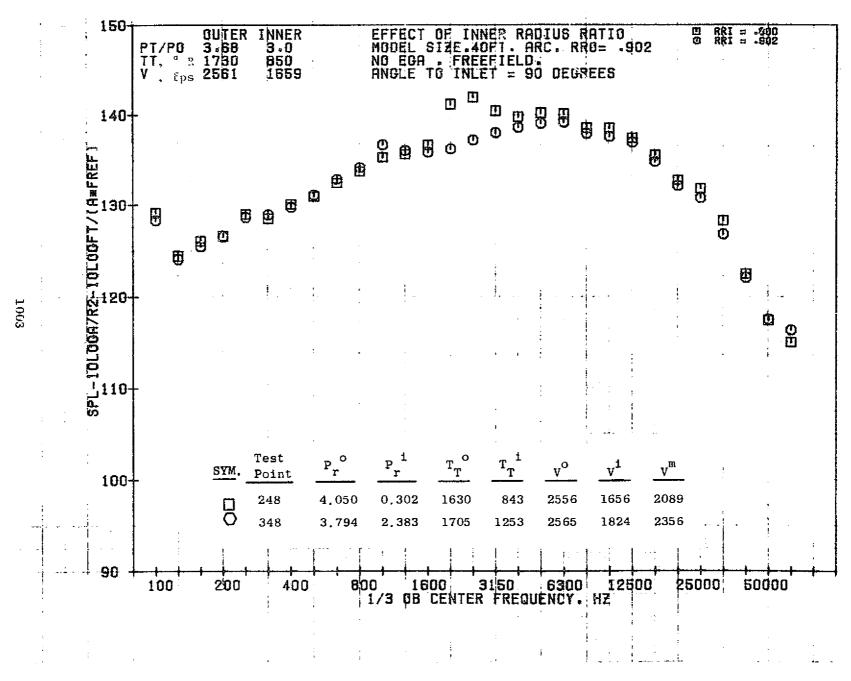
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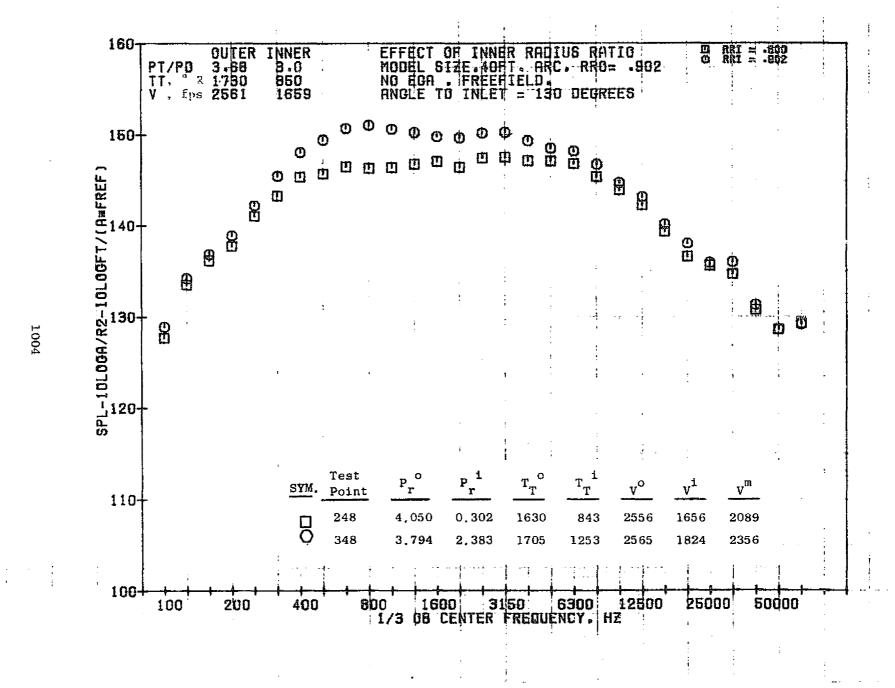


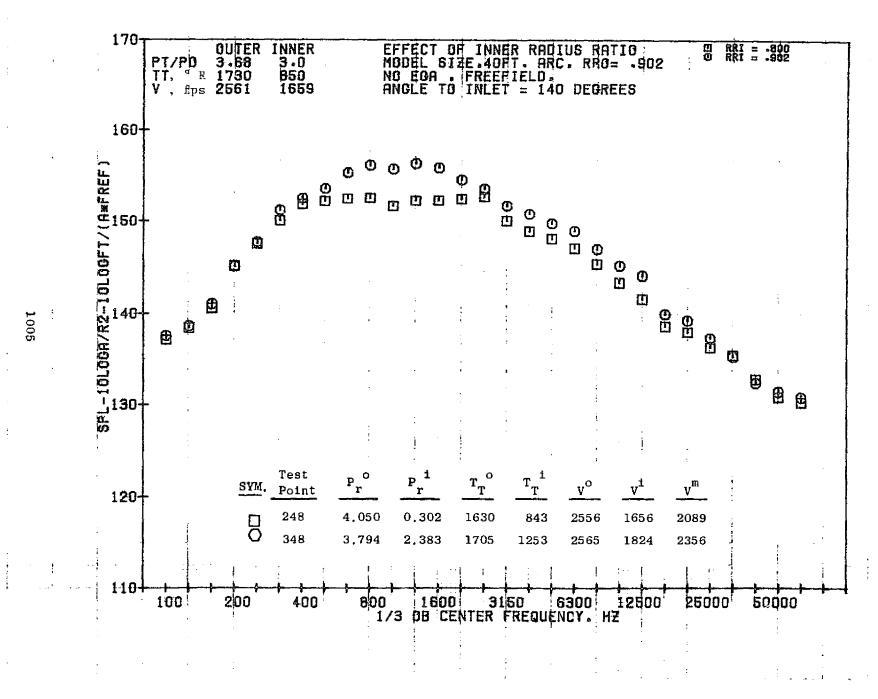


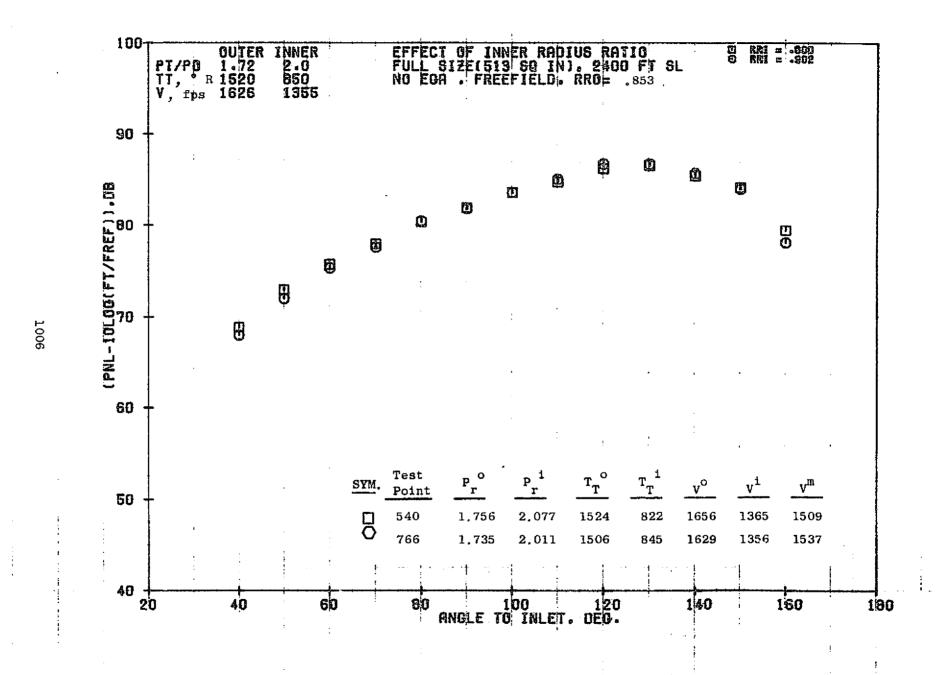


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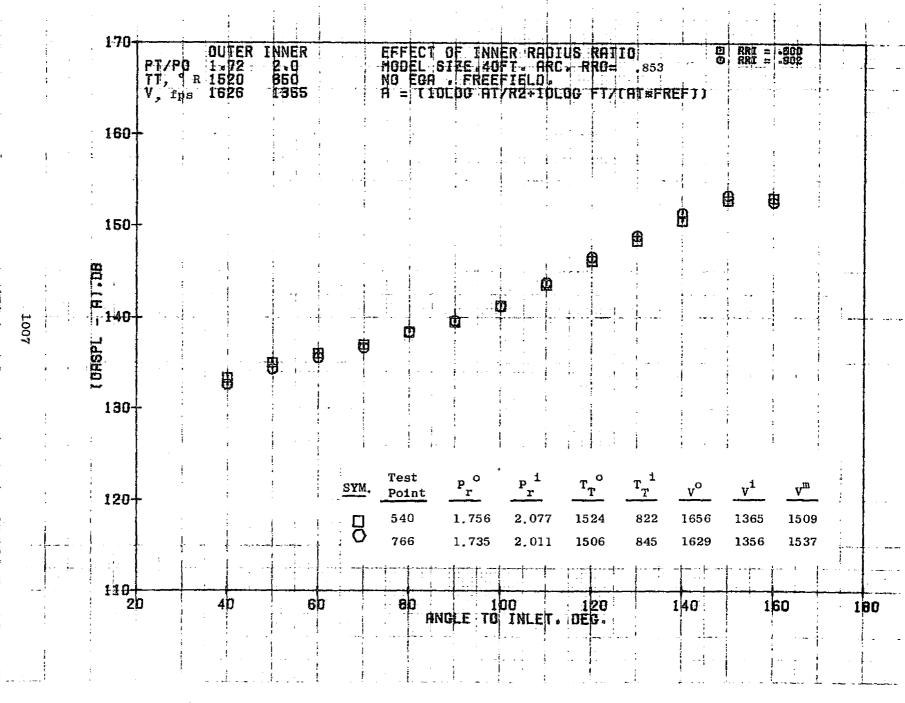


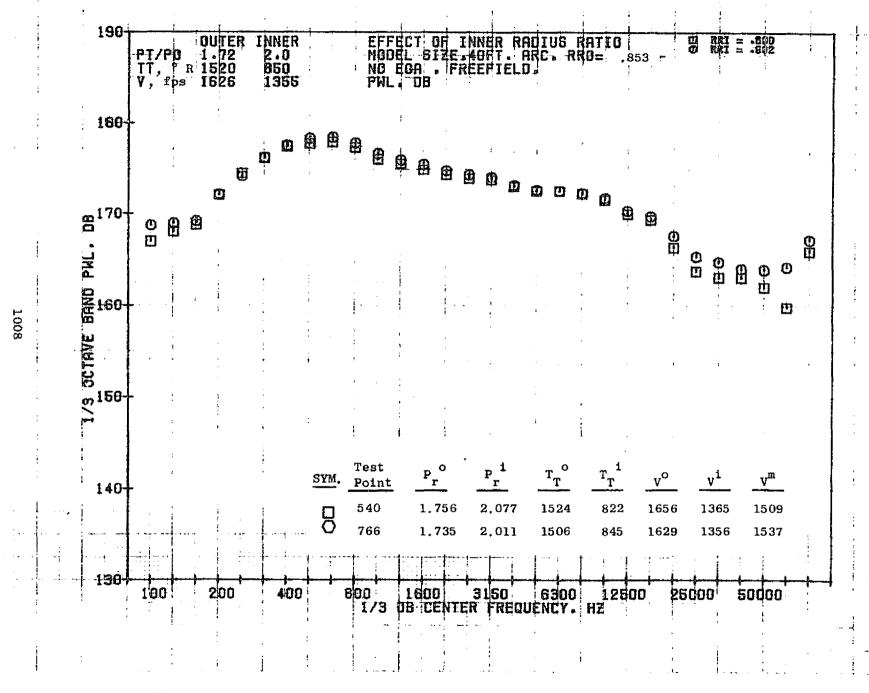


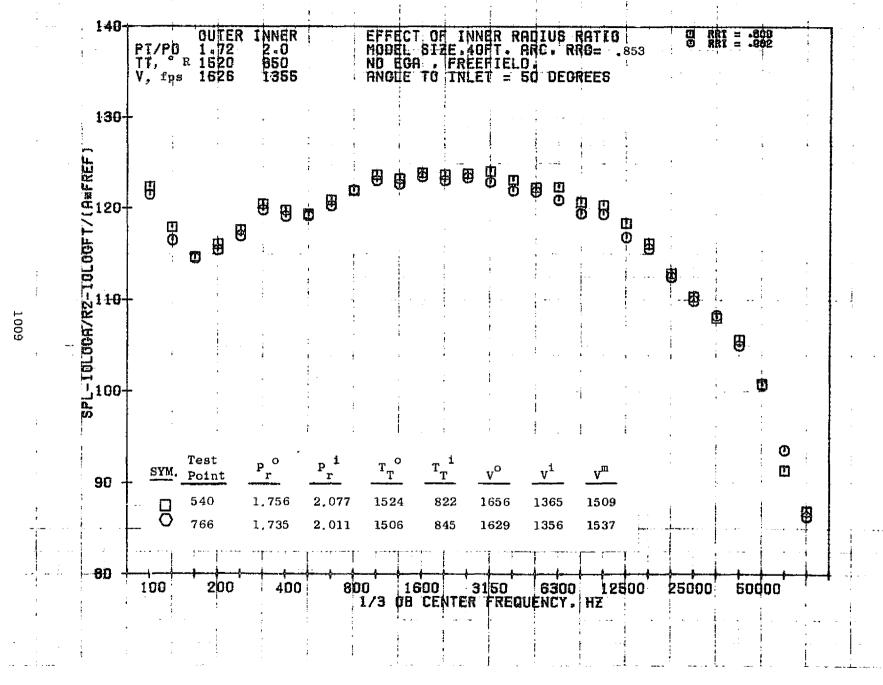


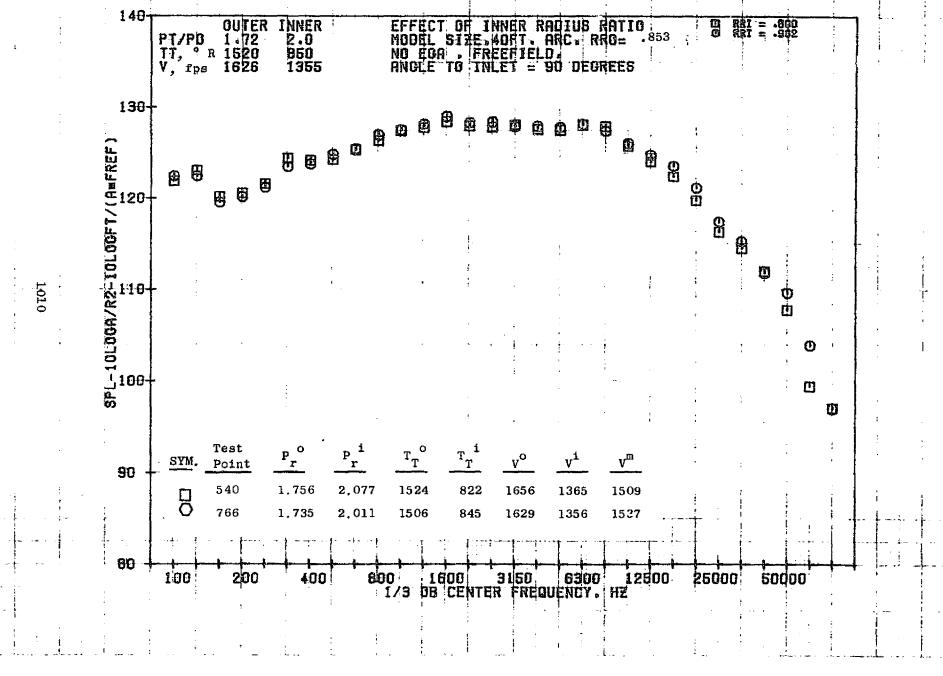


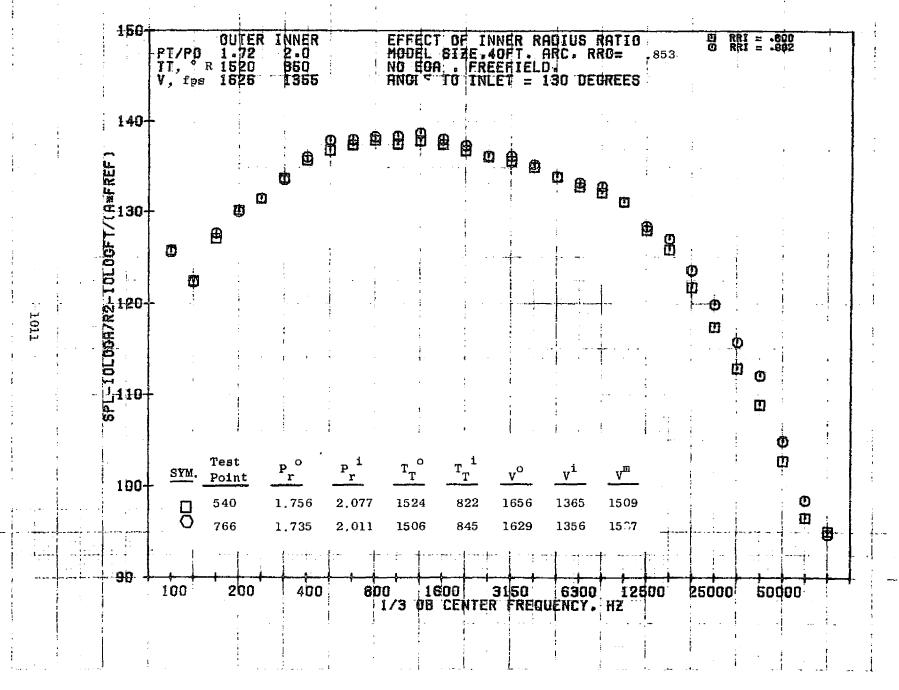
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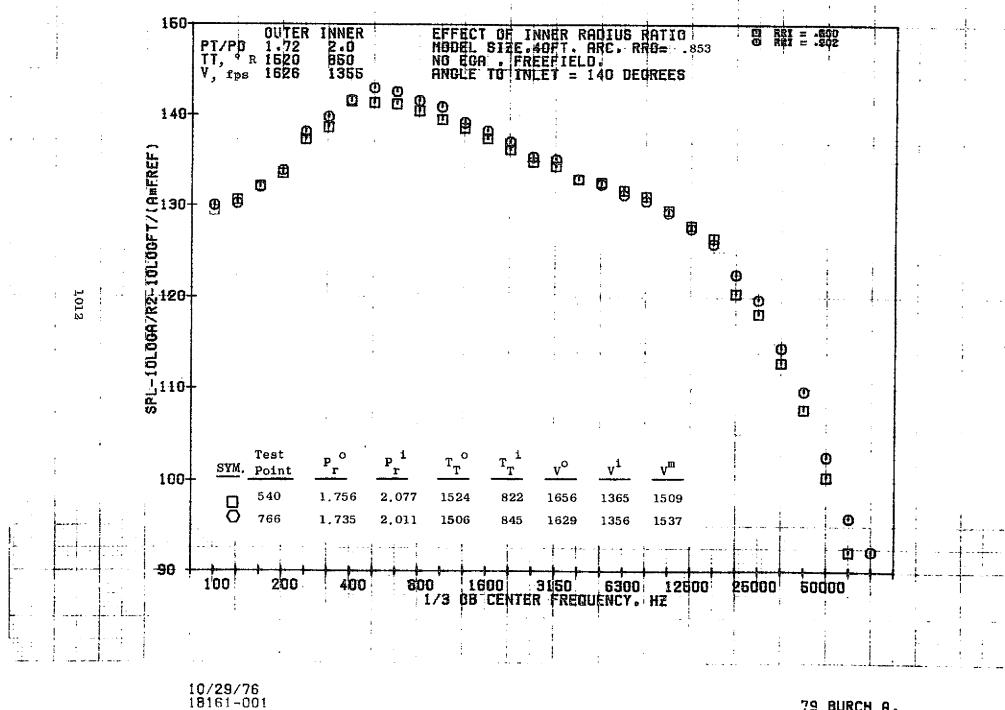


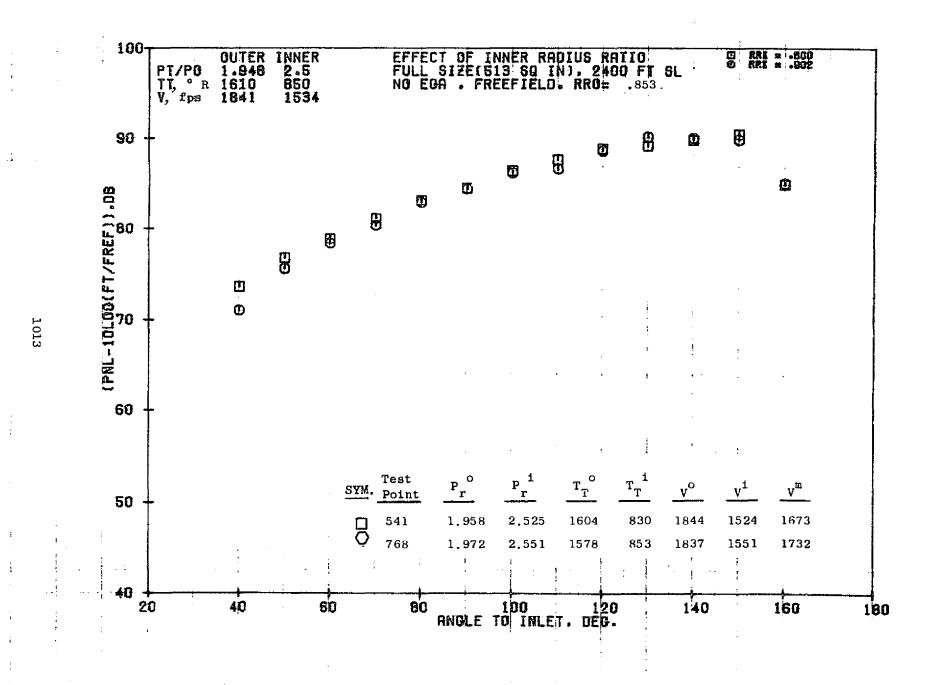




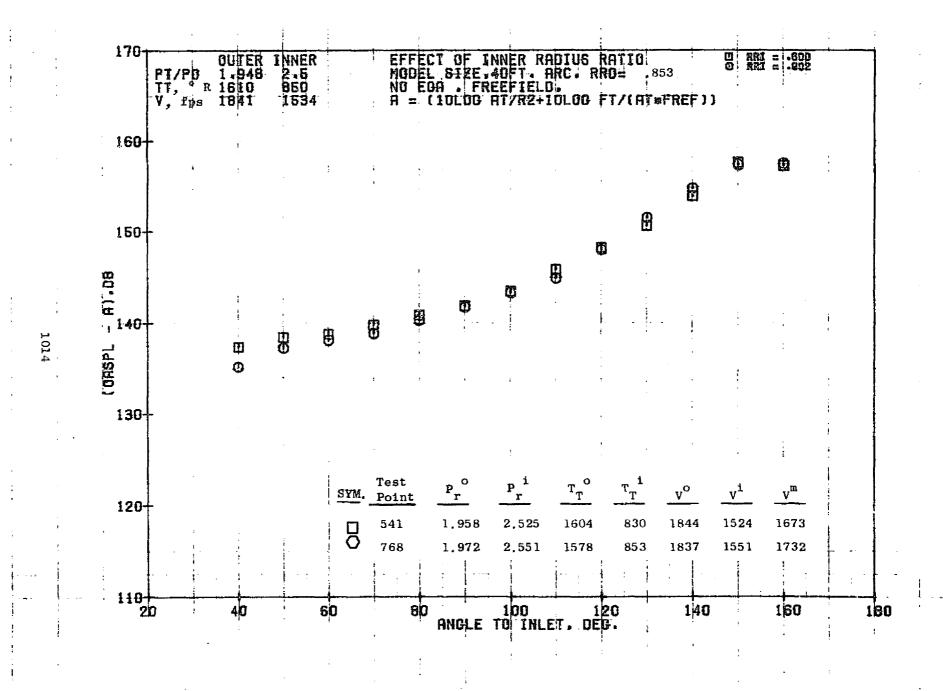




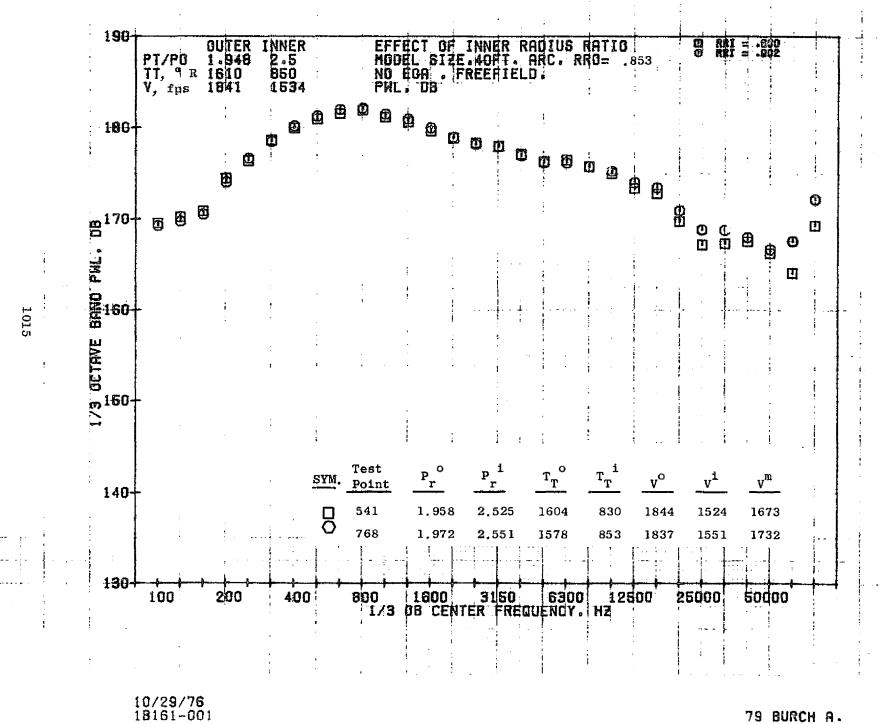


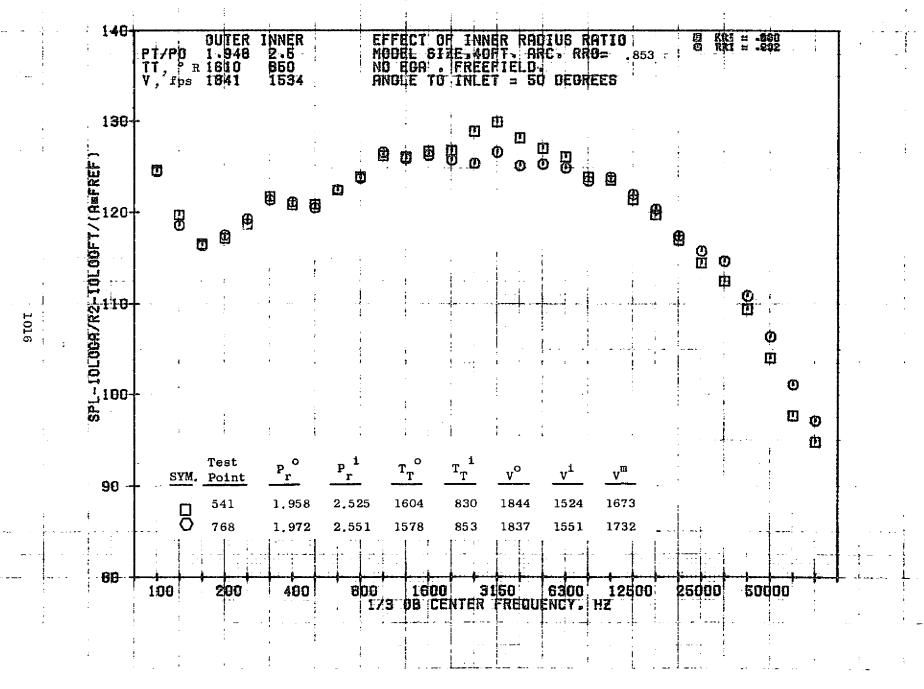


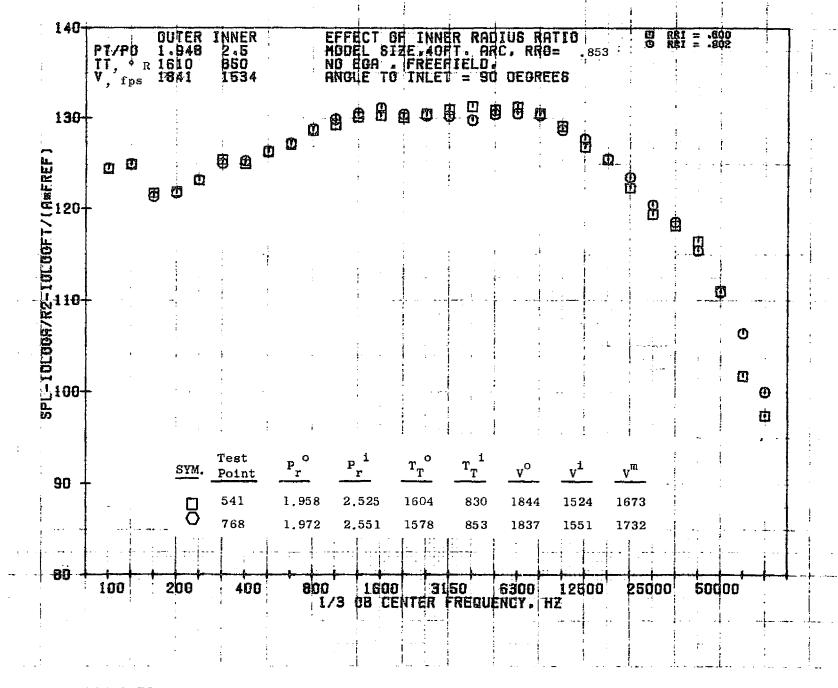
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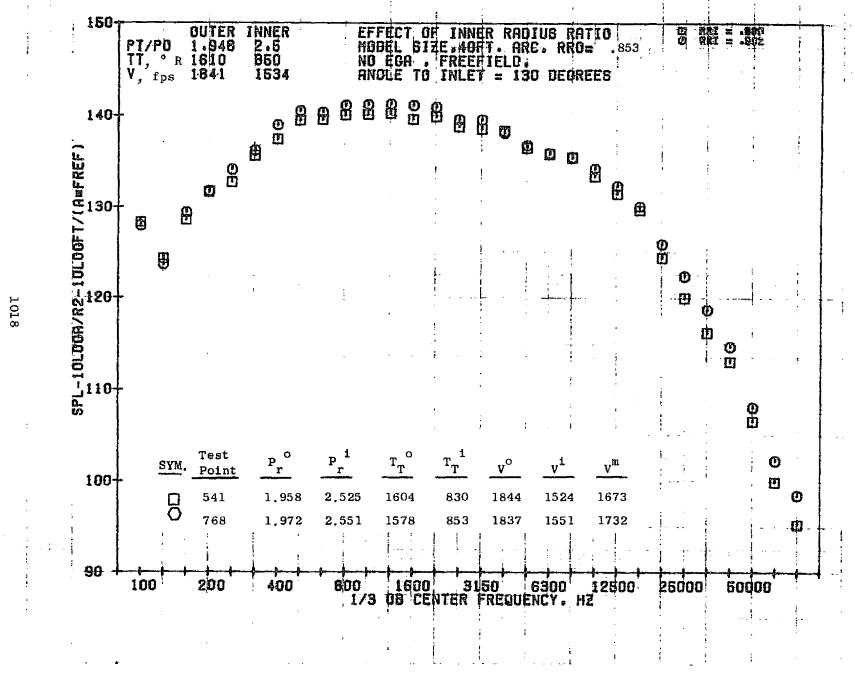


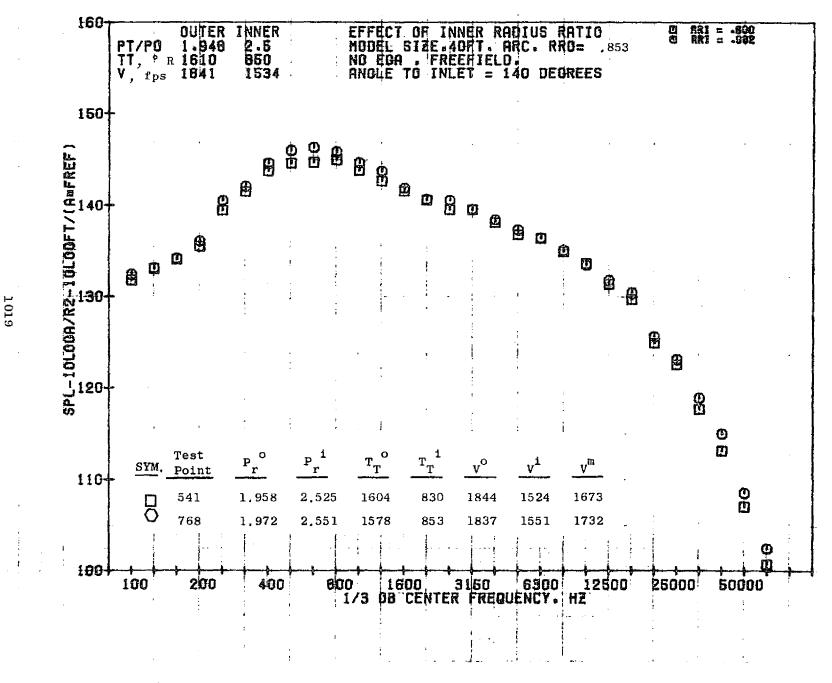
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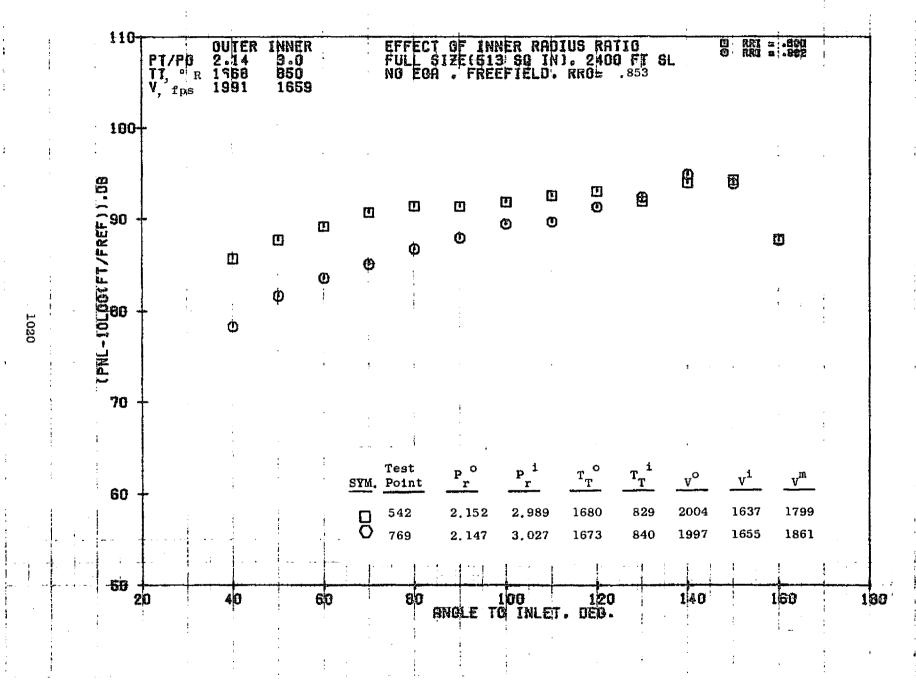


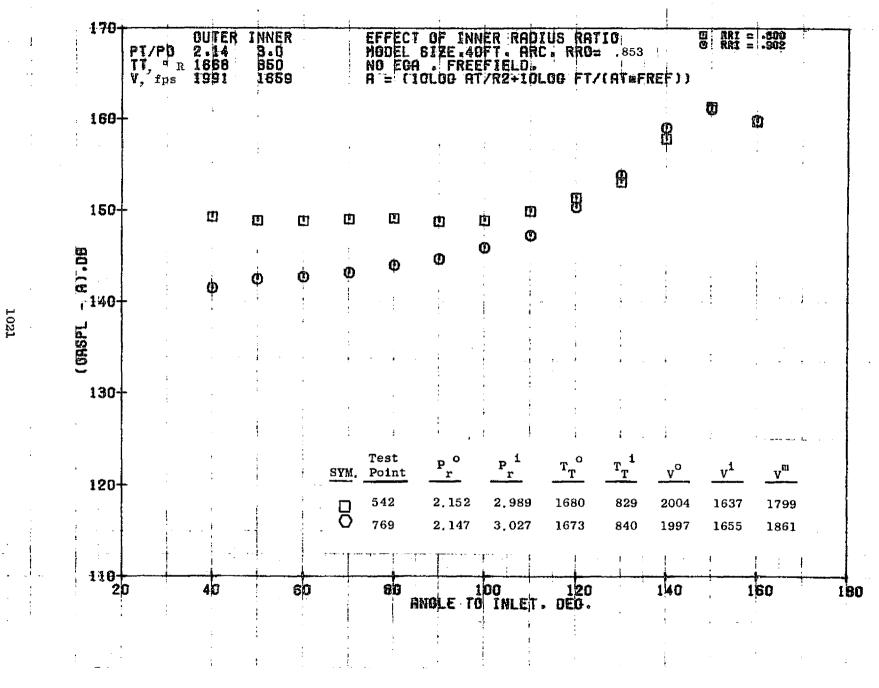


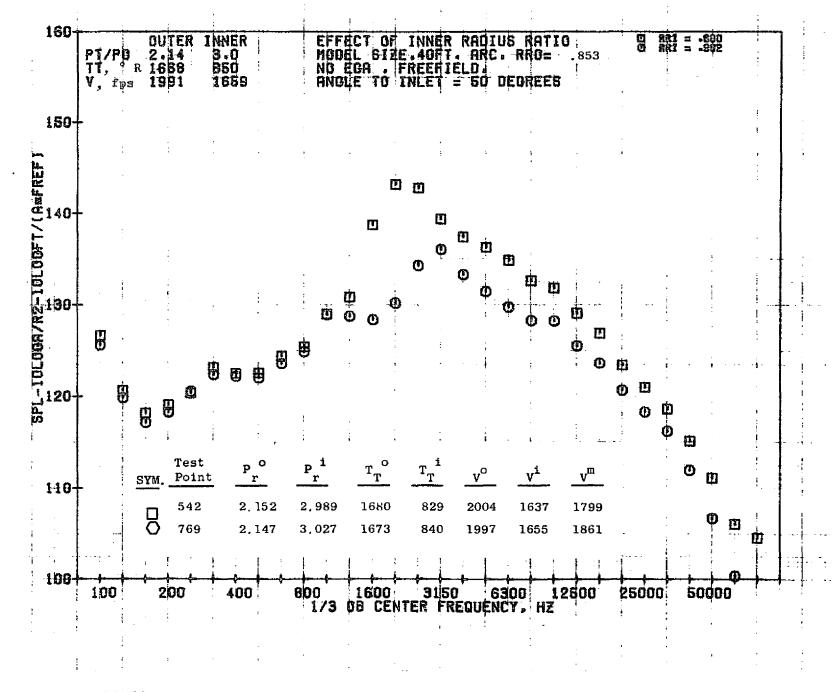


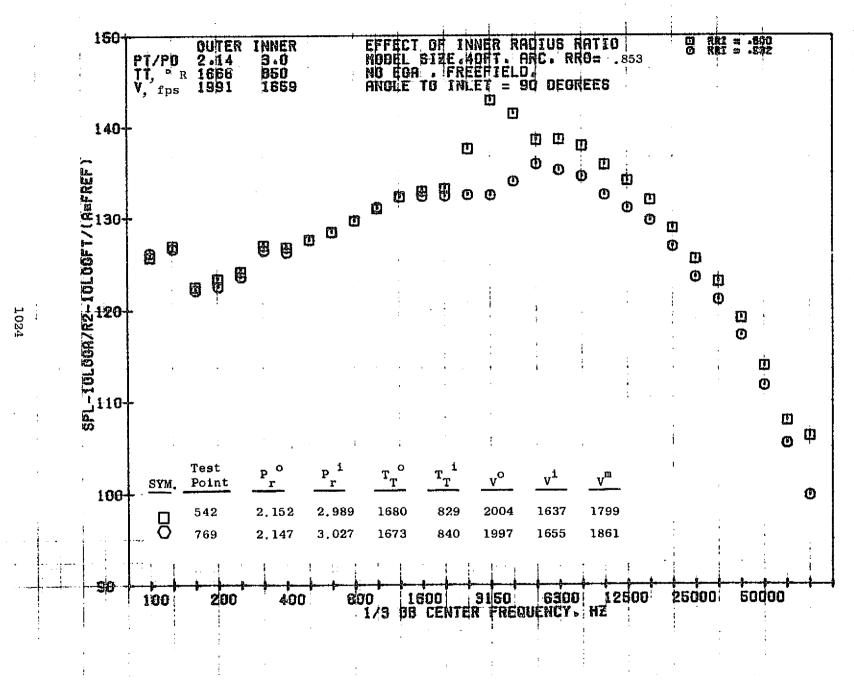


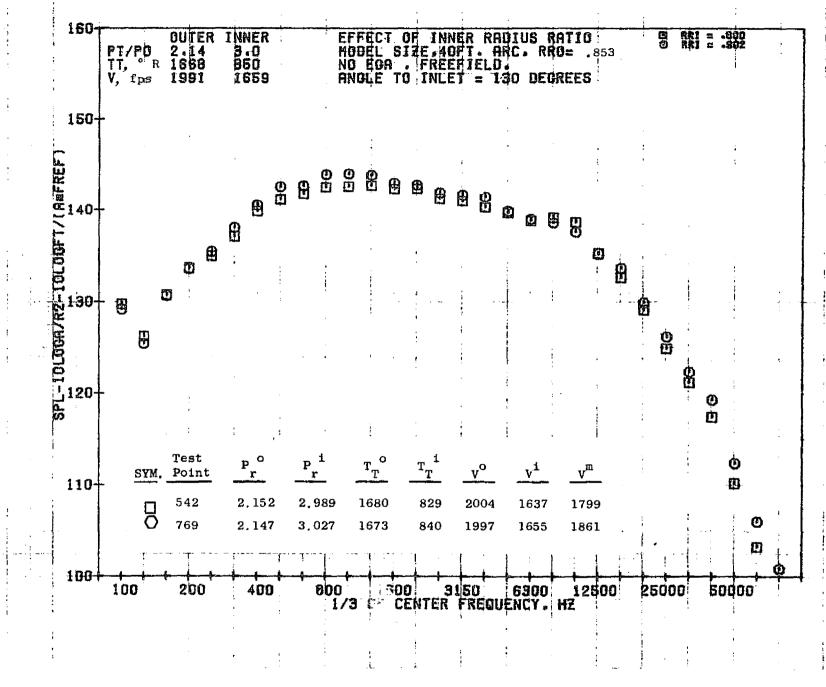




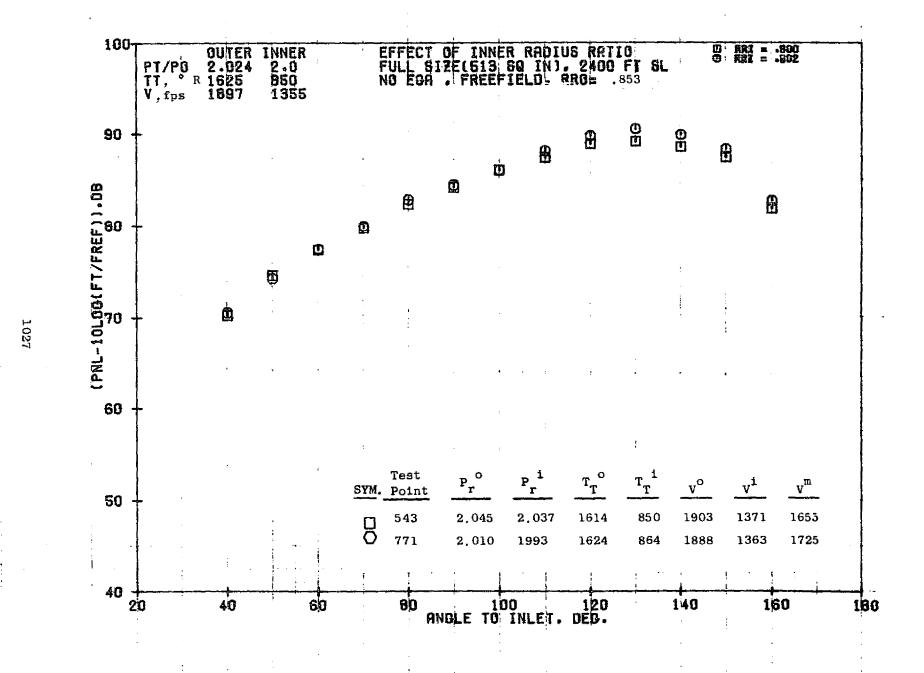




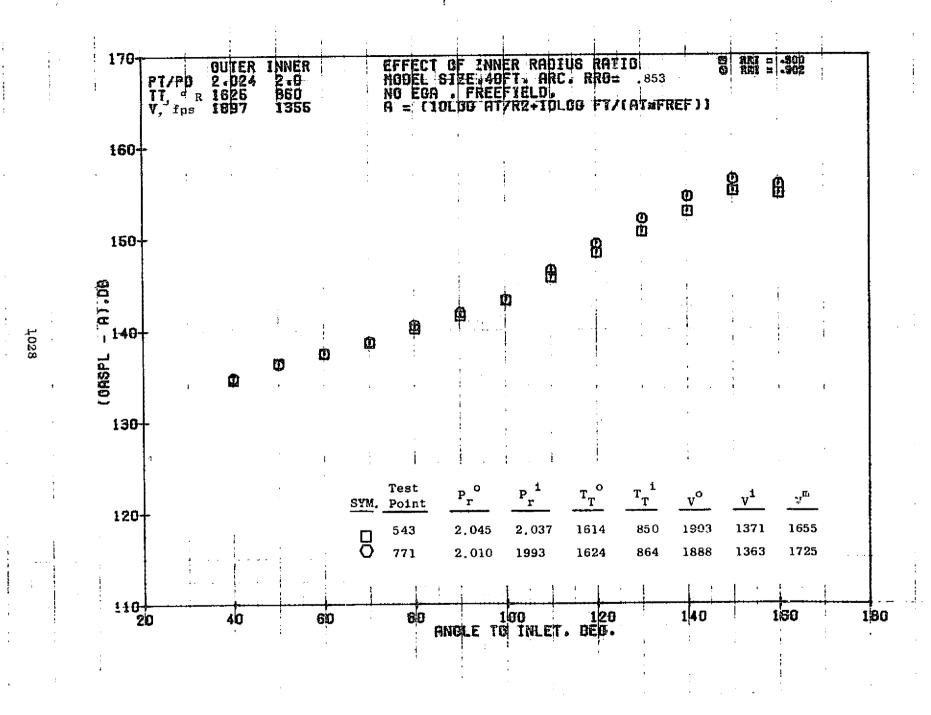


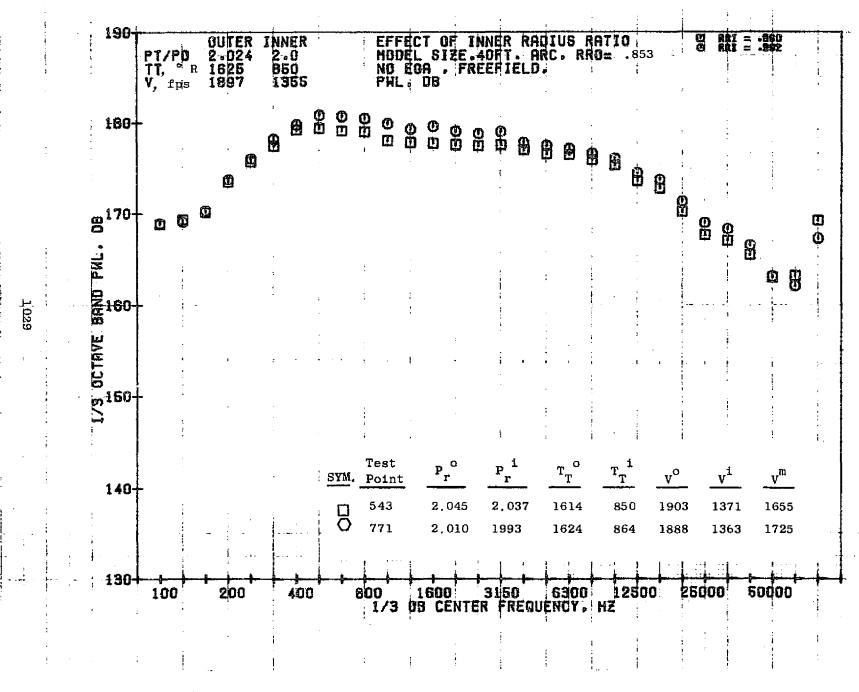


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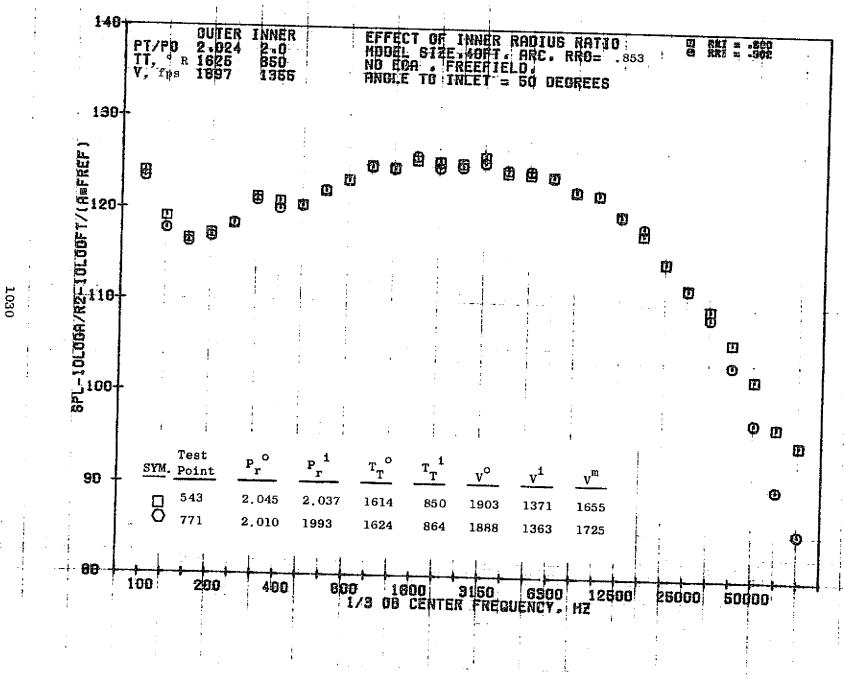


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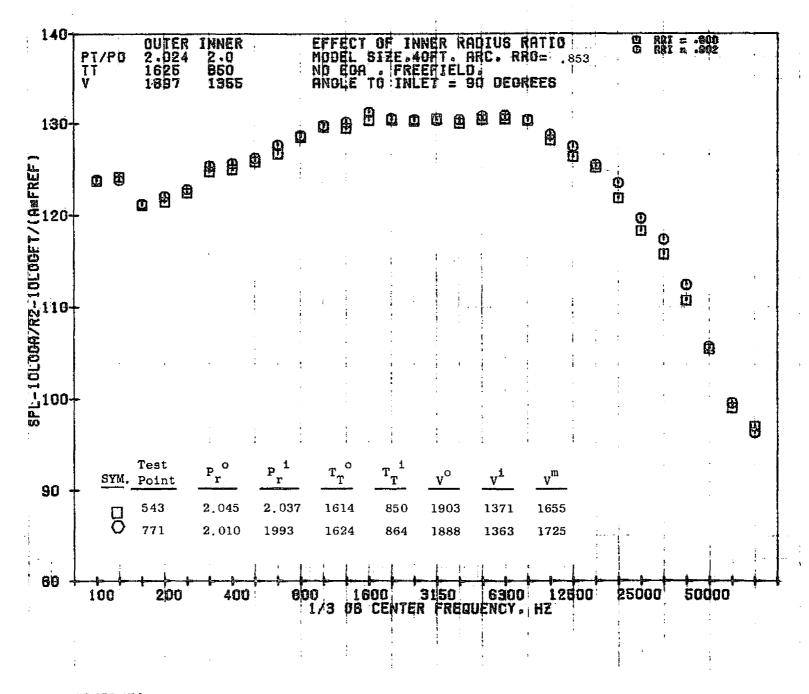




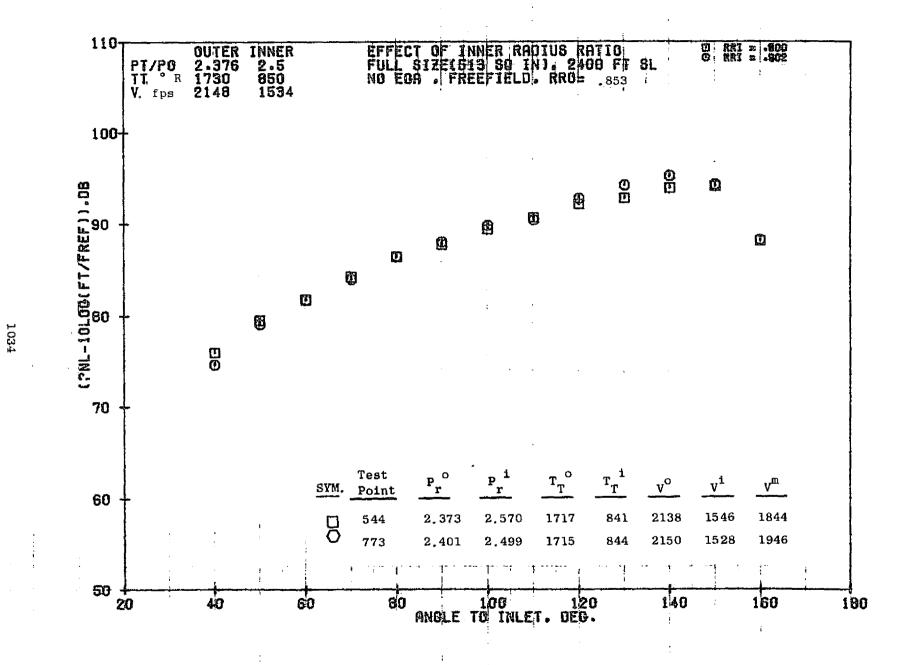
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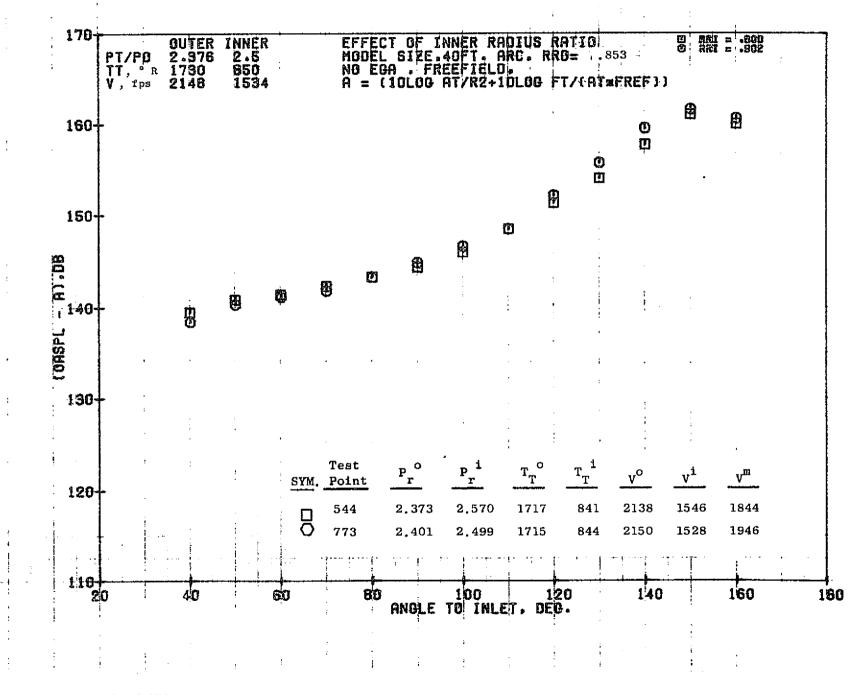


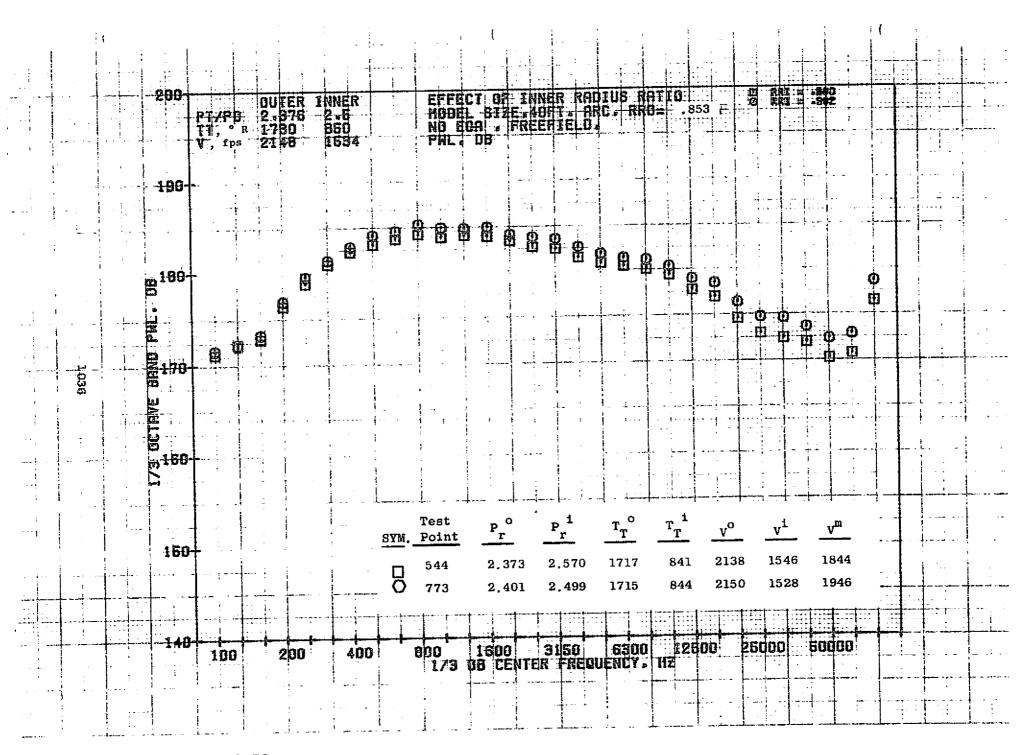
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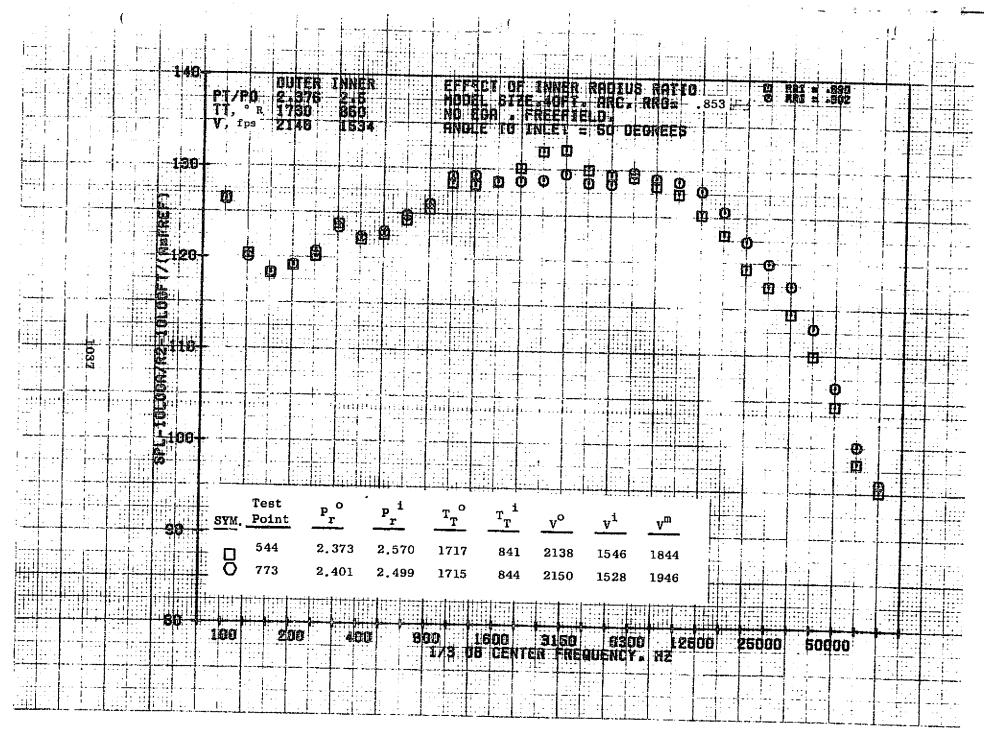


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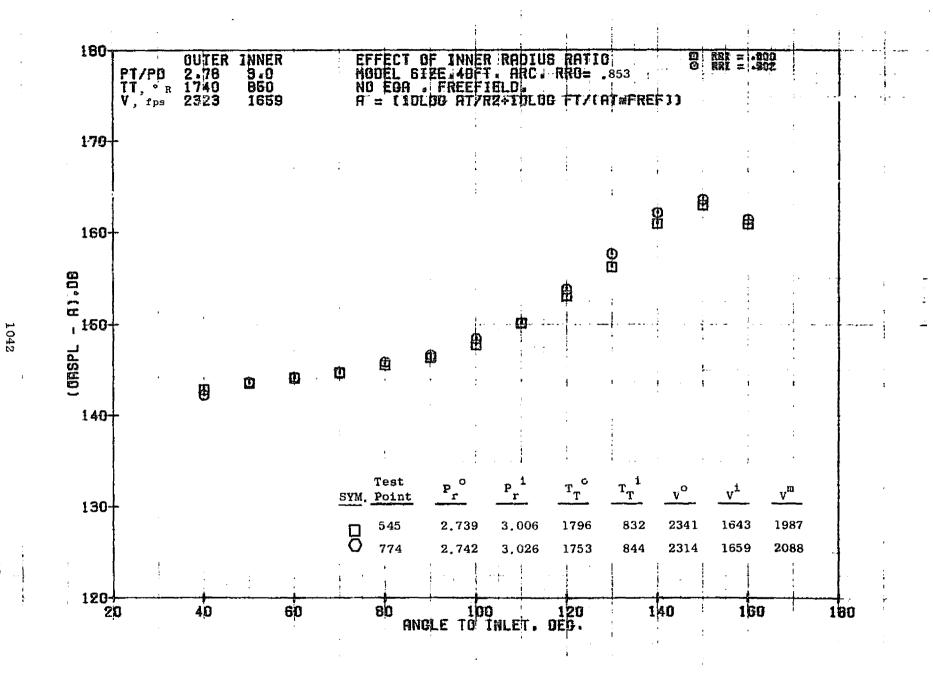


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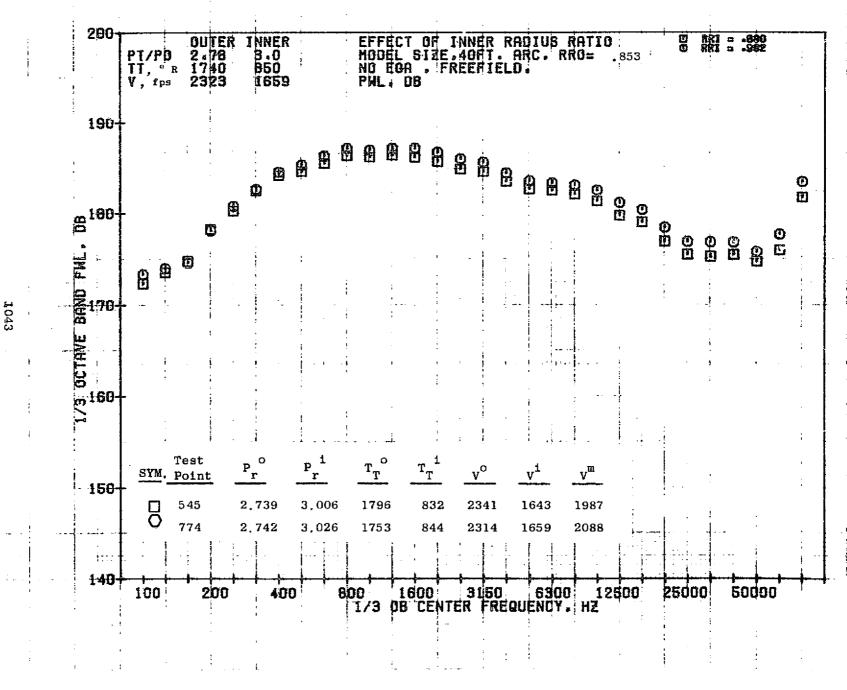
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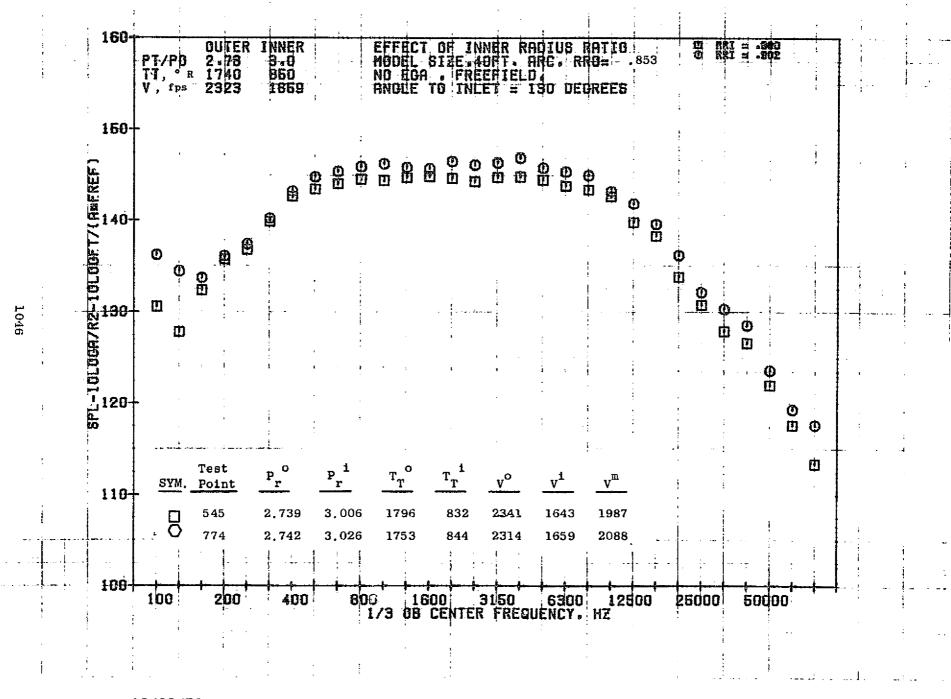
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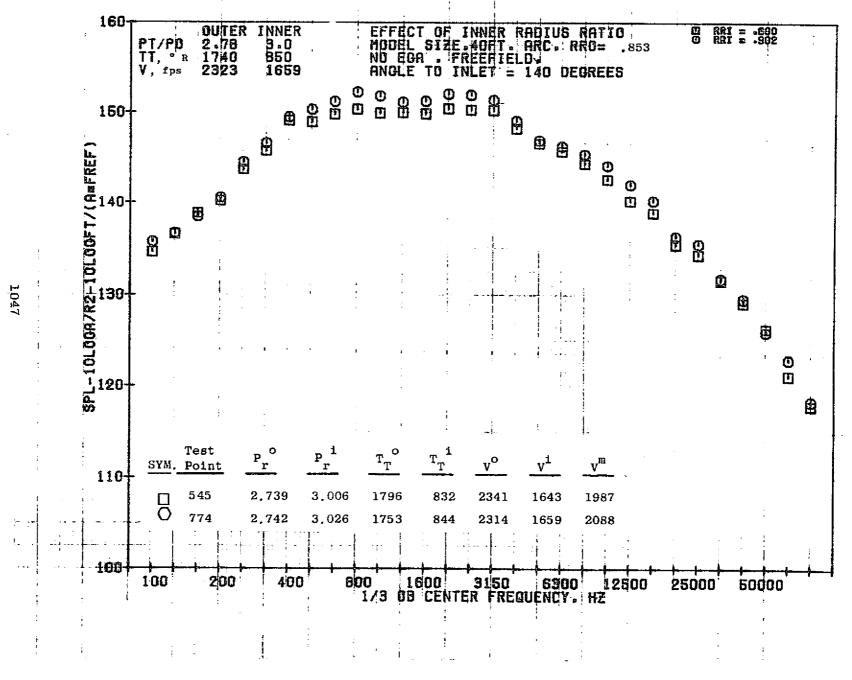


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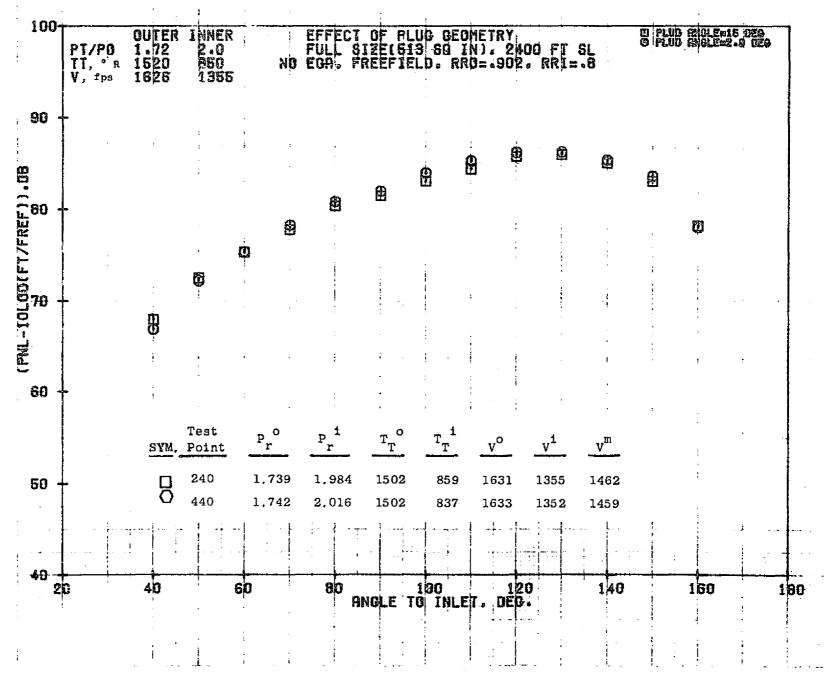
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7.4.3 Effect of Plug Geometry

The effect of plug geometry is examined in this section. Configurations 2 and 4 have the same inner and outer radius ratios but different plug geometries. Configuration 2 has a smooth plug contour while Configuration 4 has a somewhat flat plug crown.

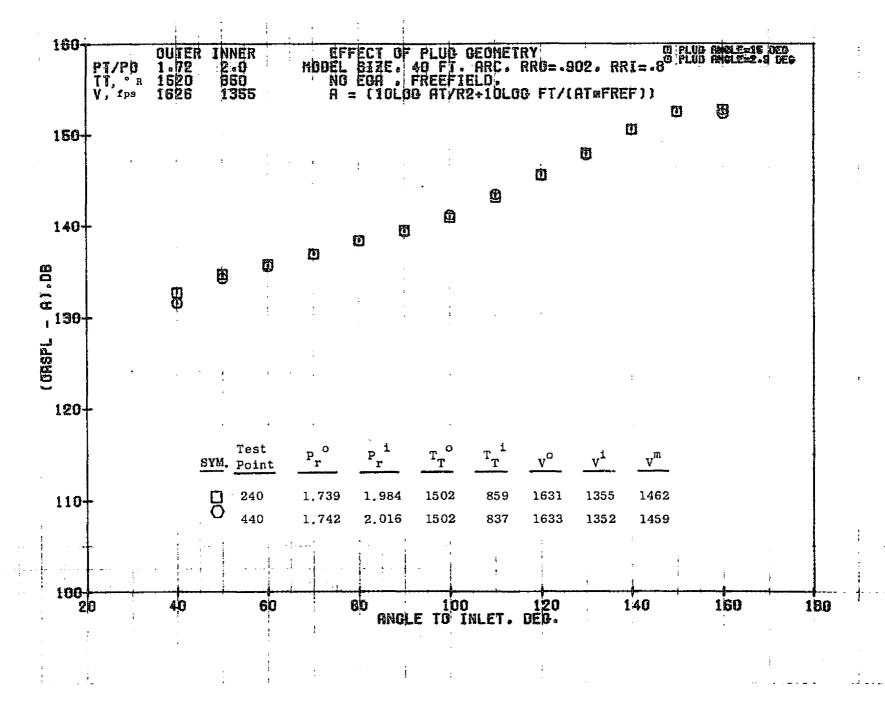


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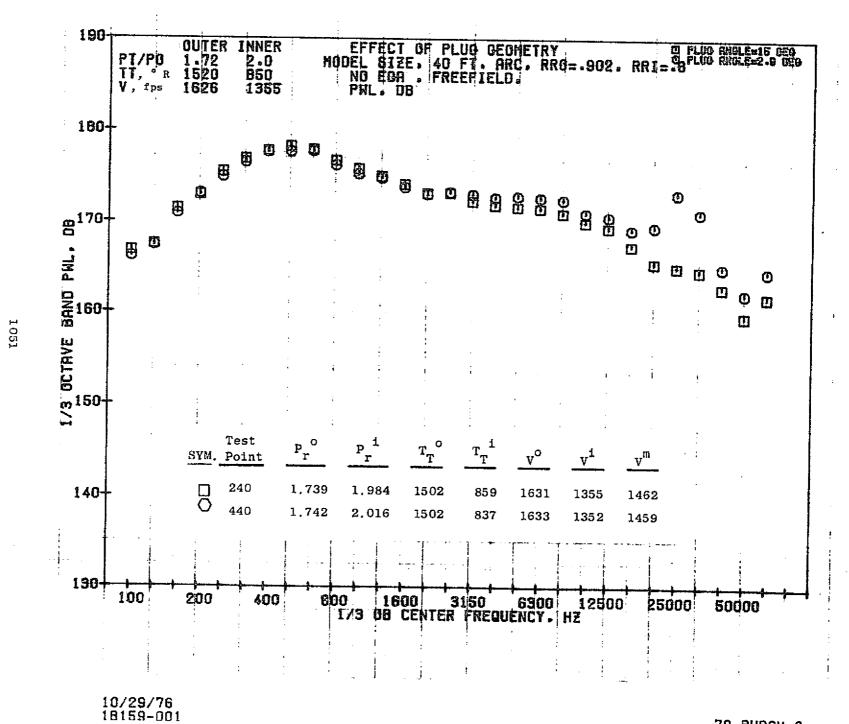
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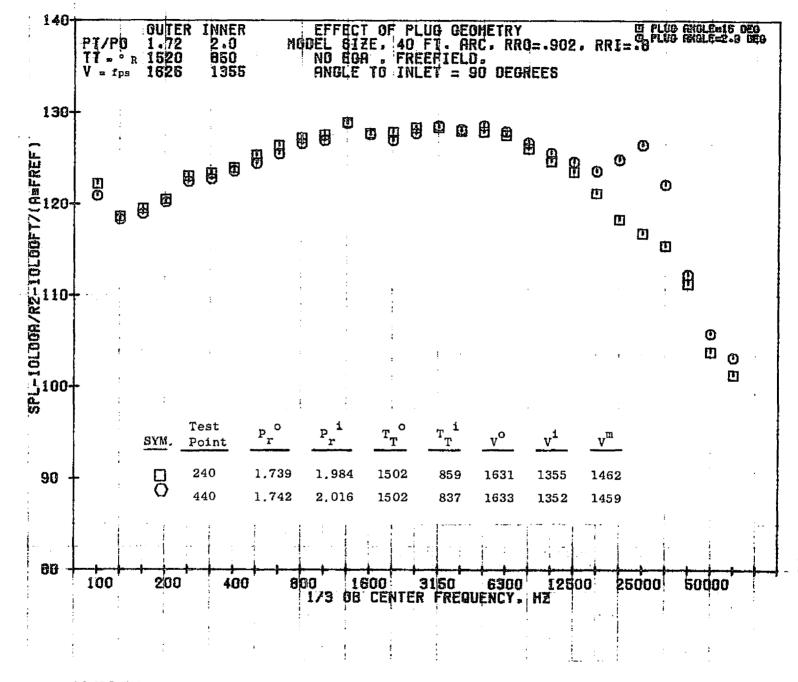
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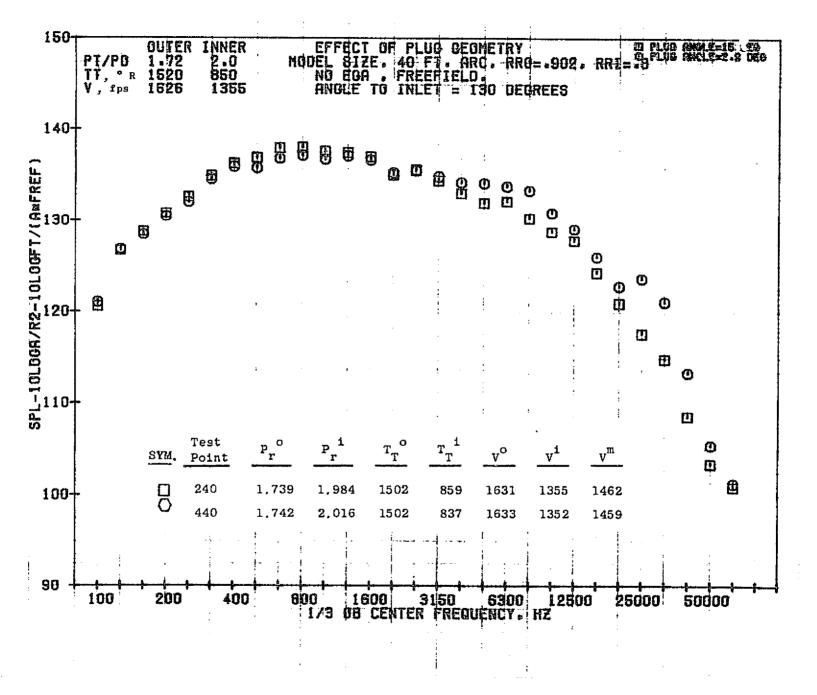
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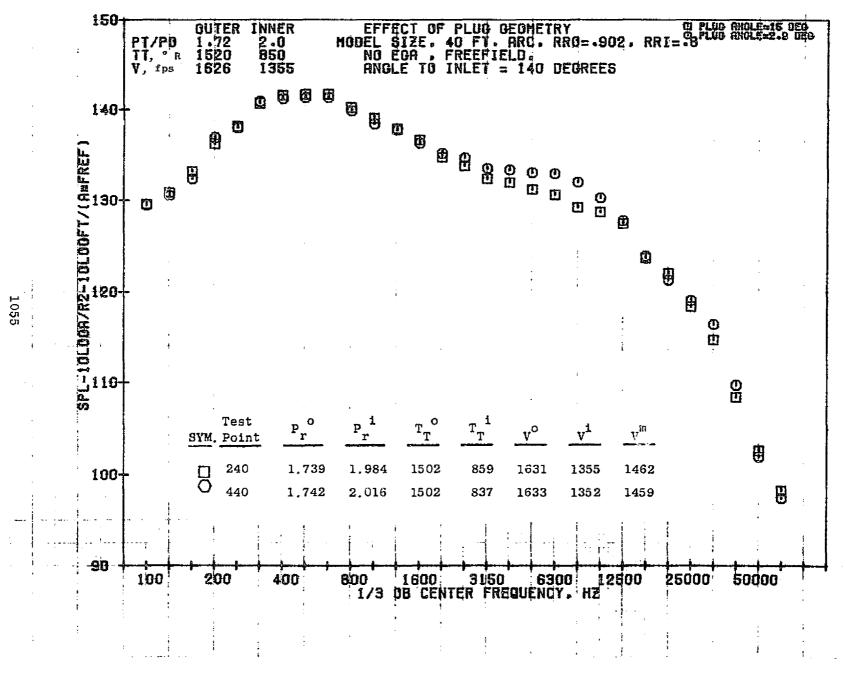
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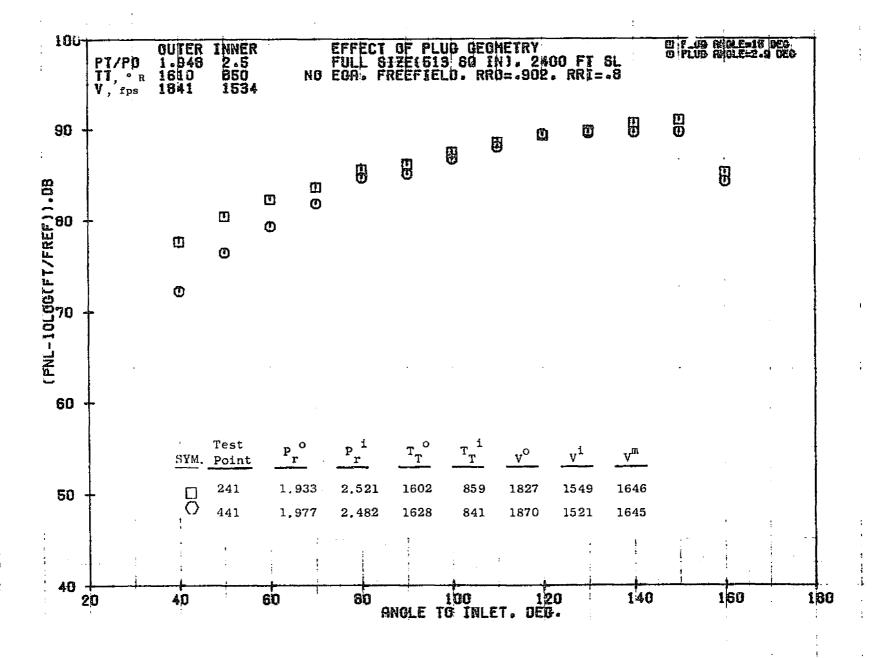


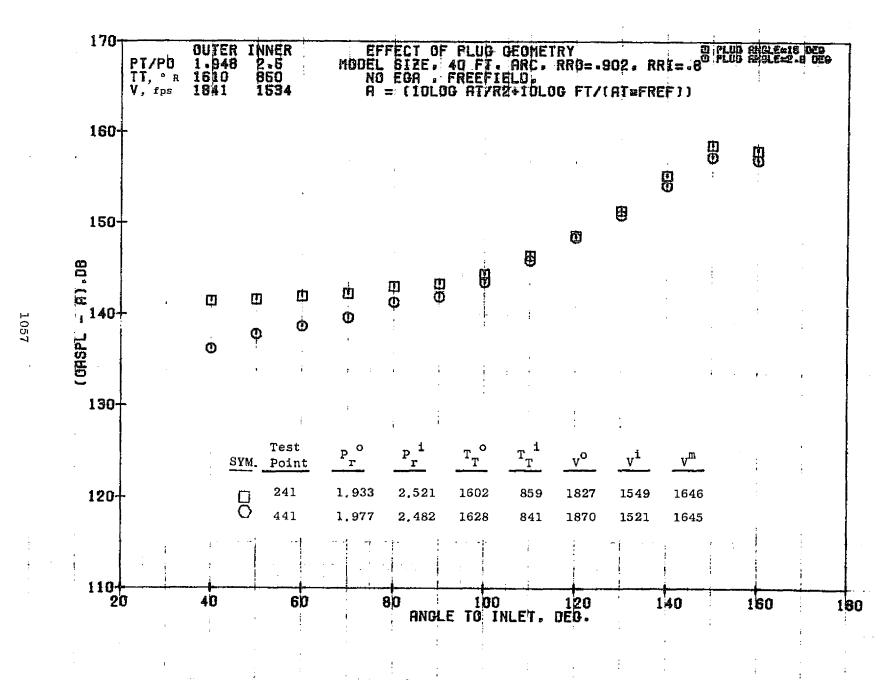


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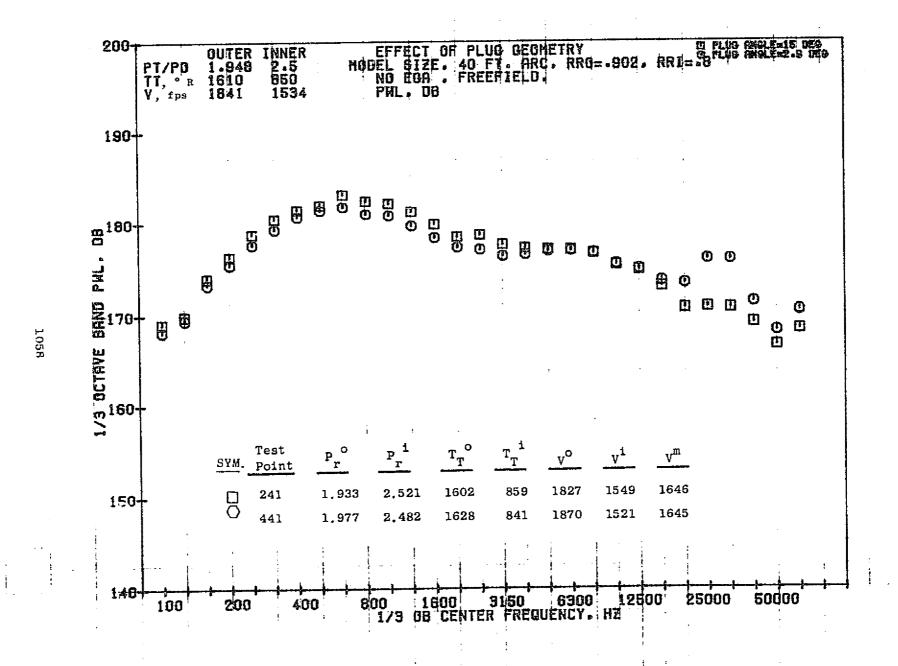


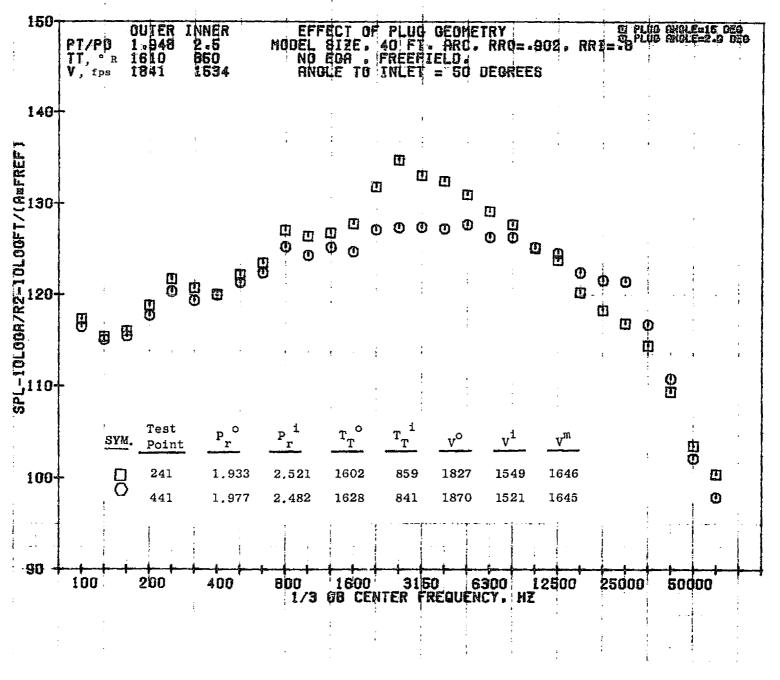
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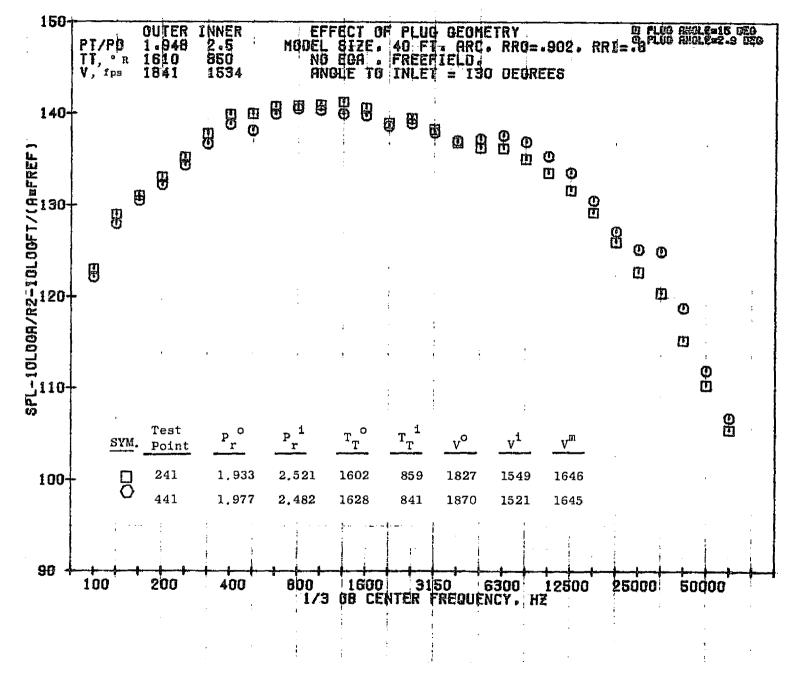


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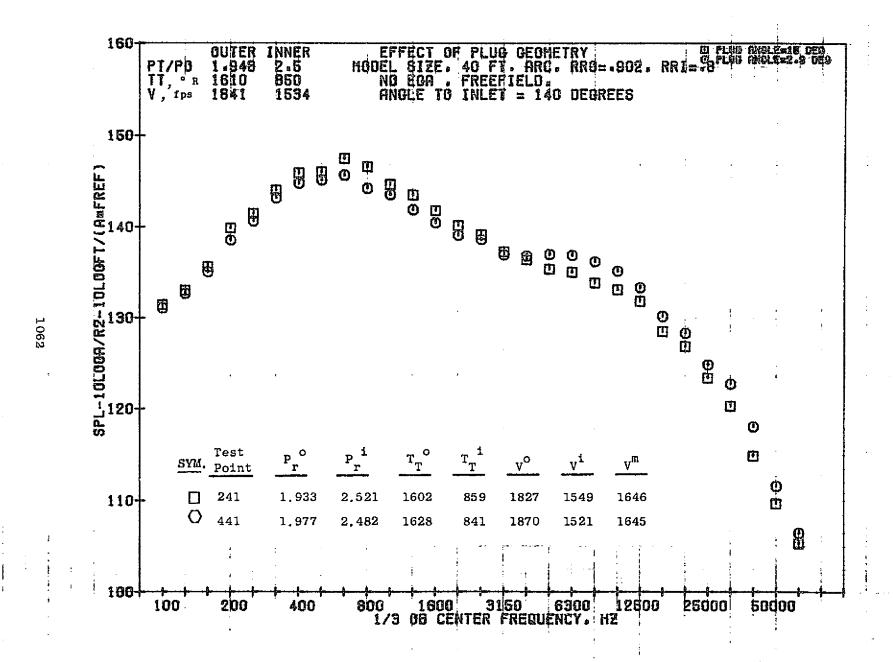


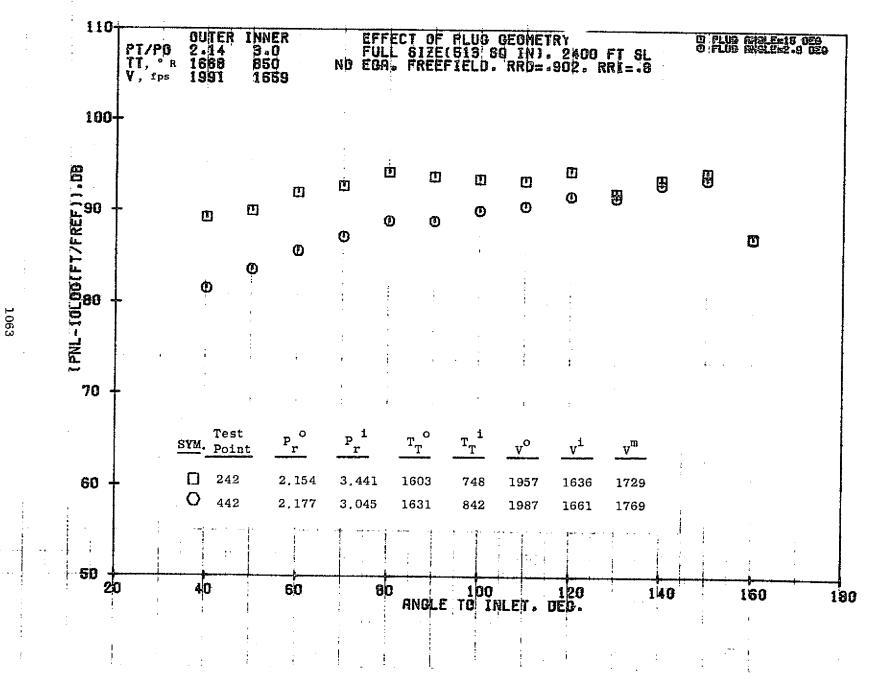


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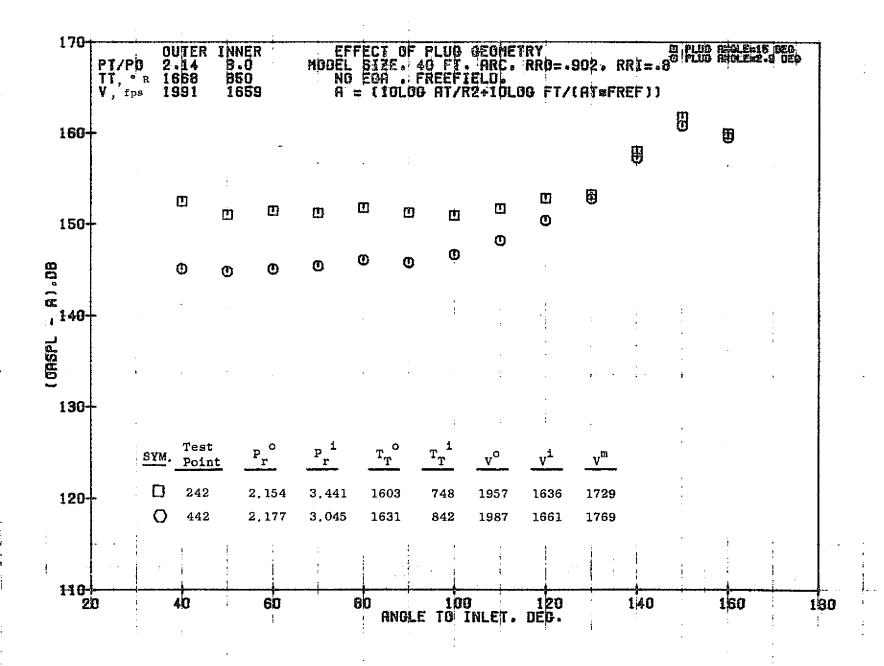


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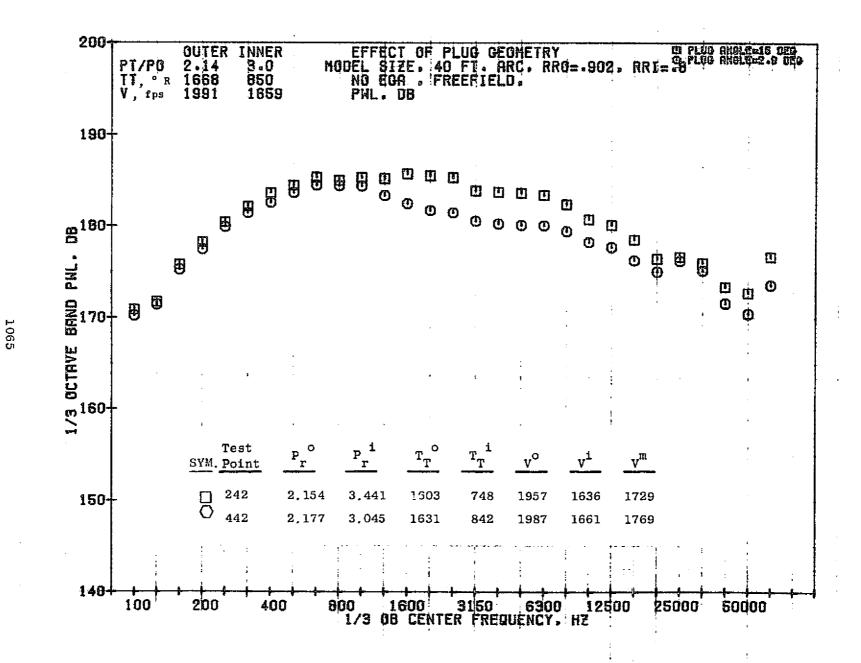




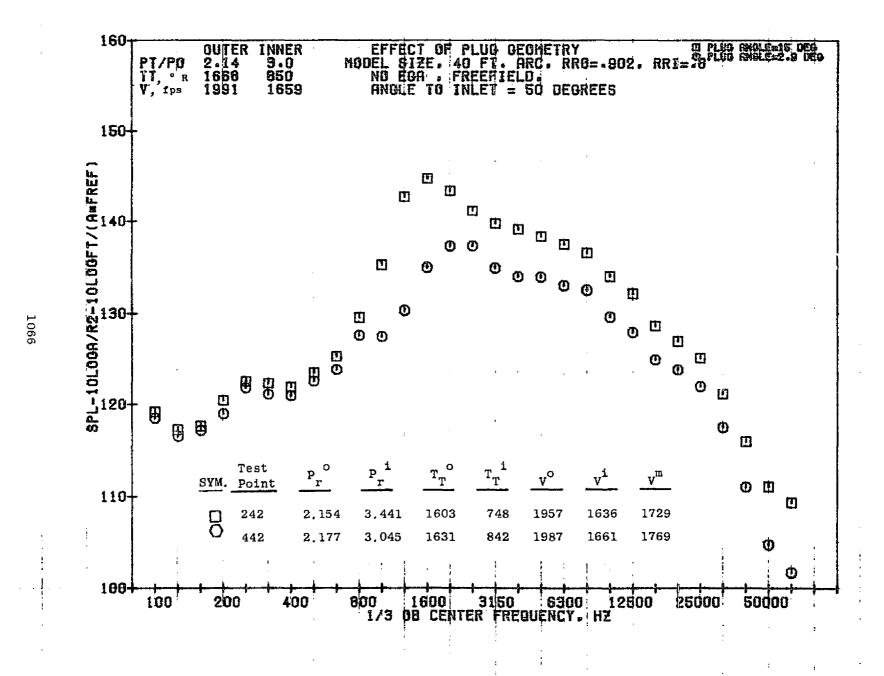
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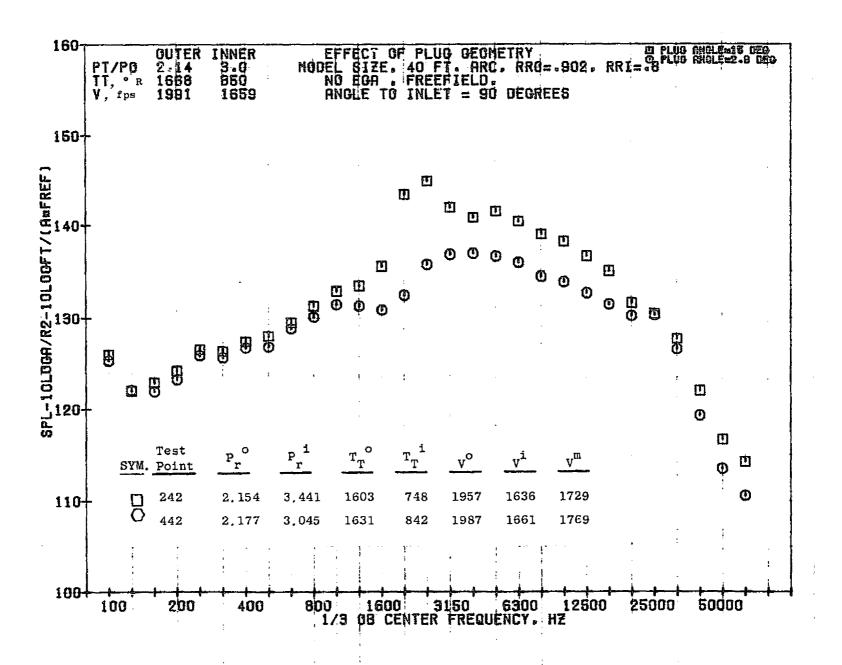
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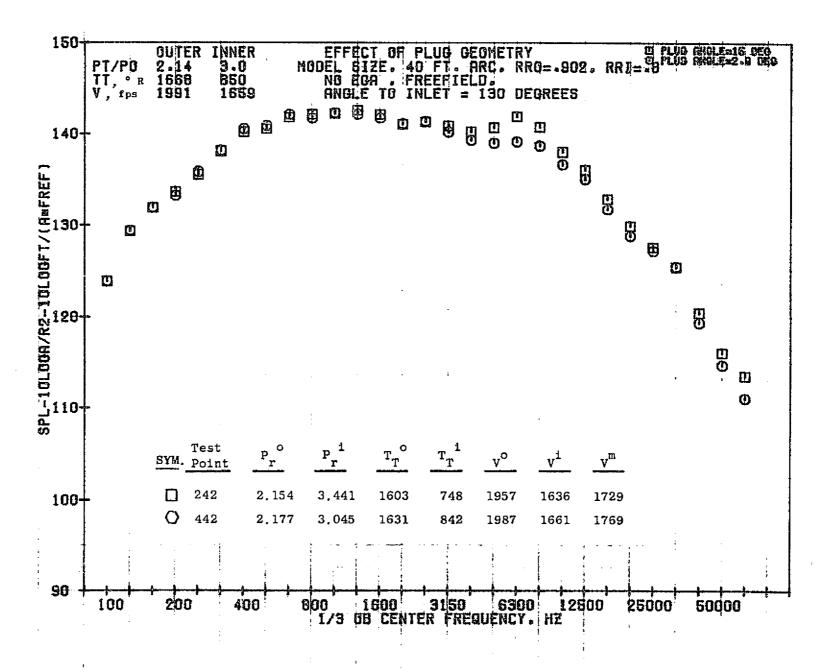


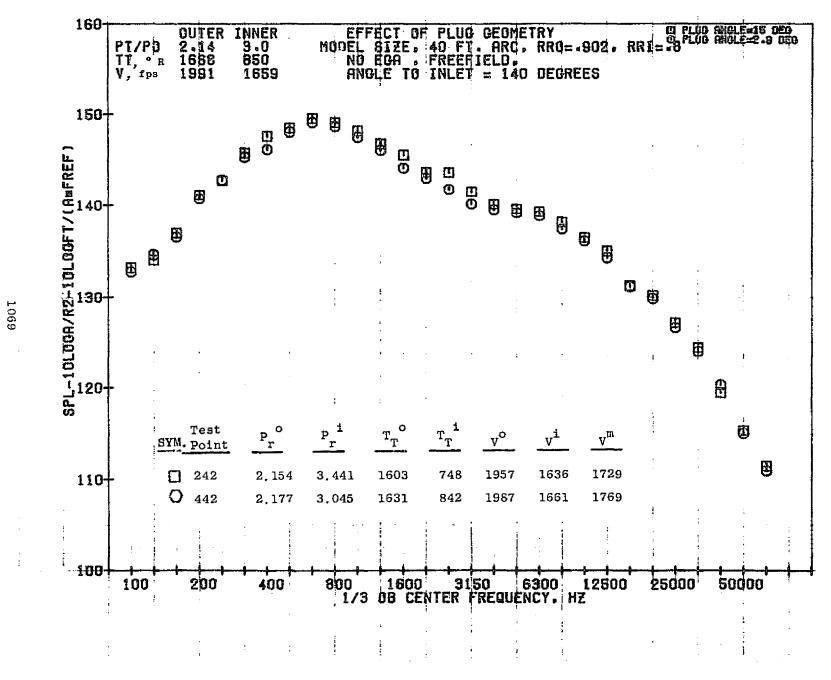




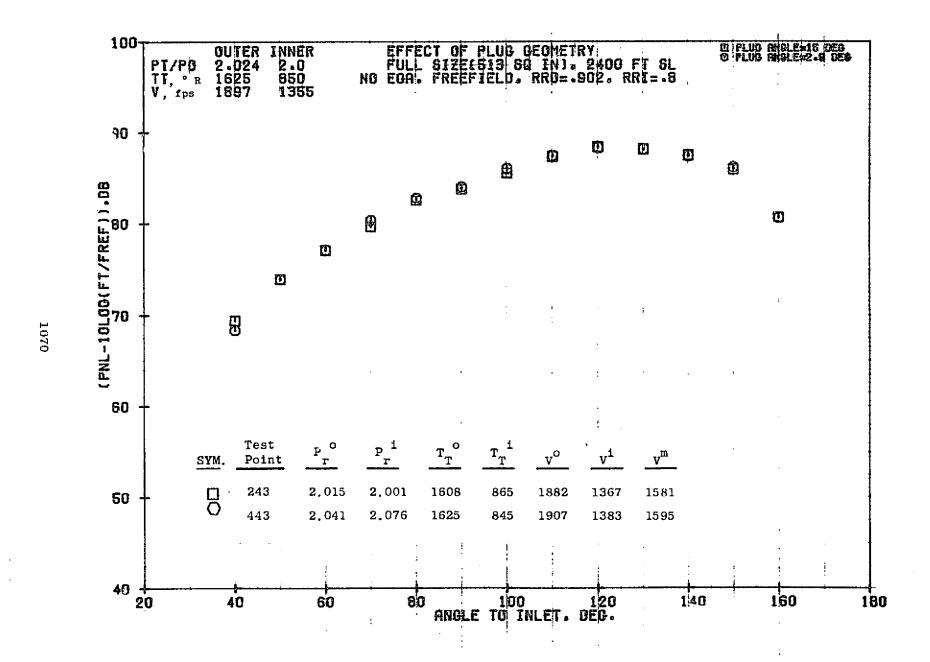


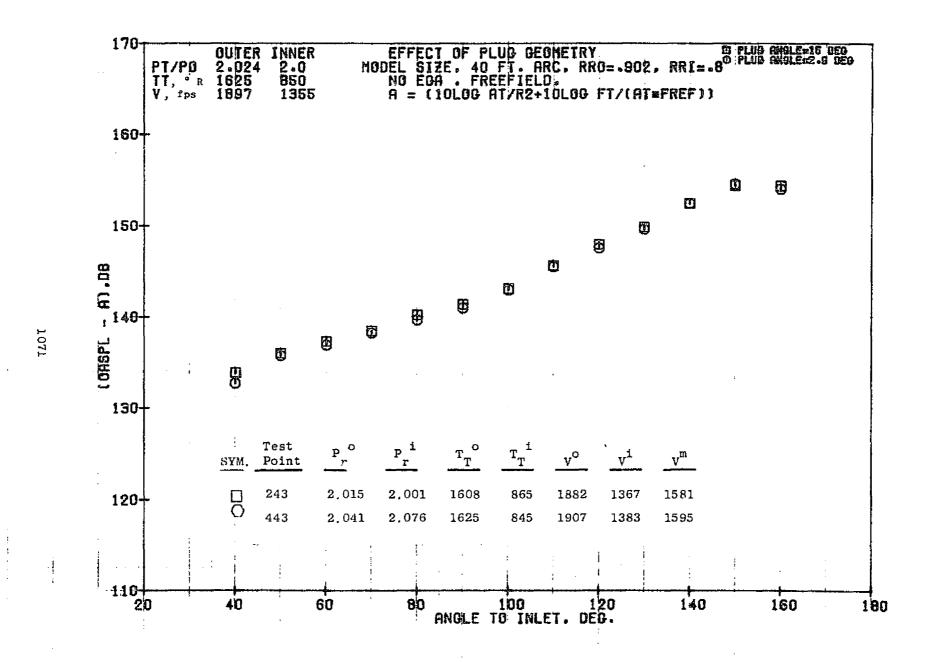
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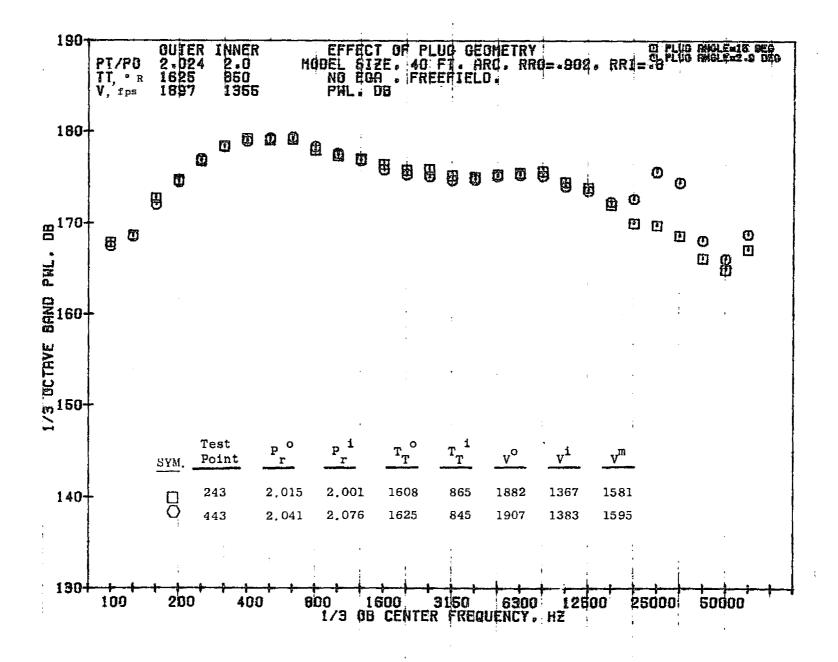




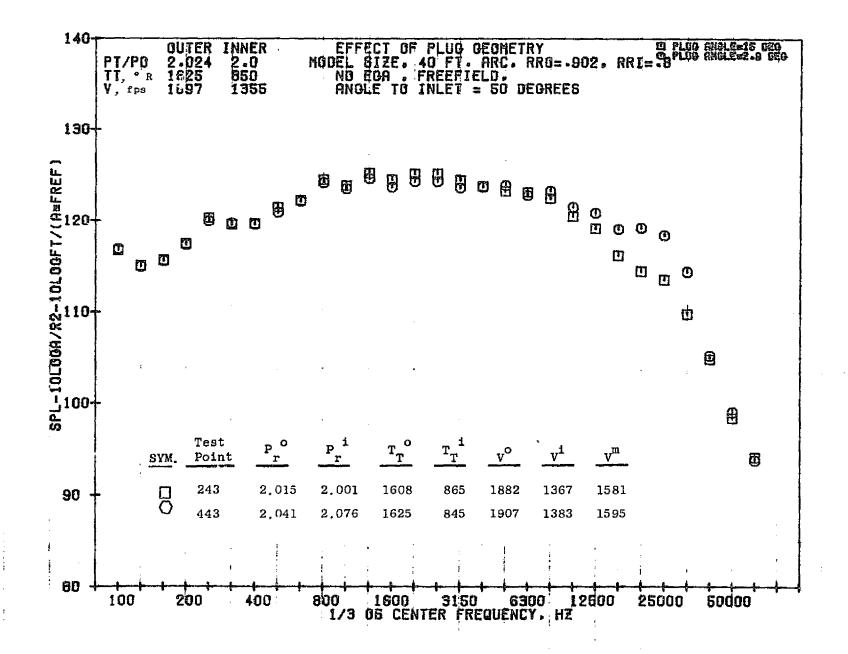
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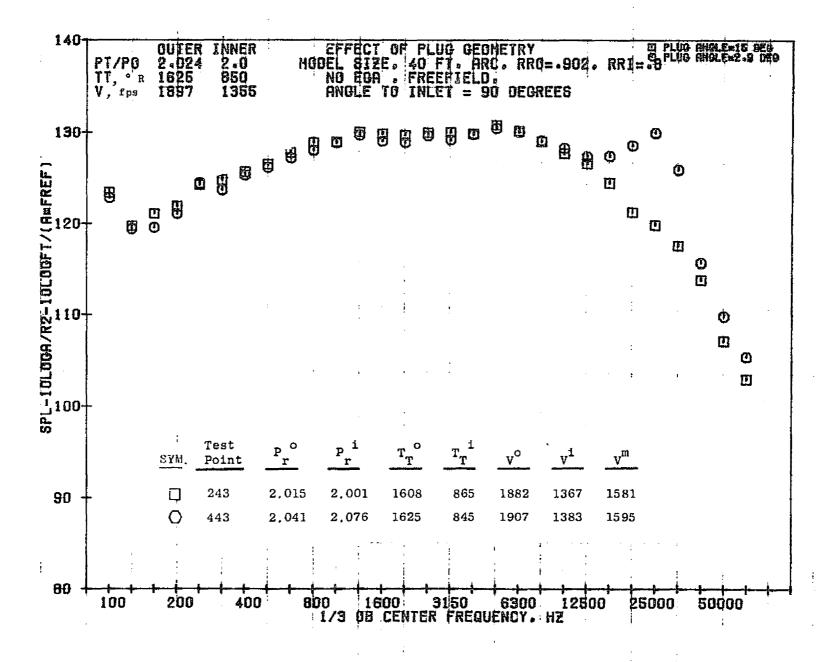






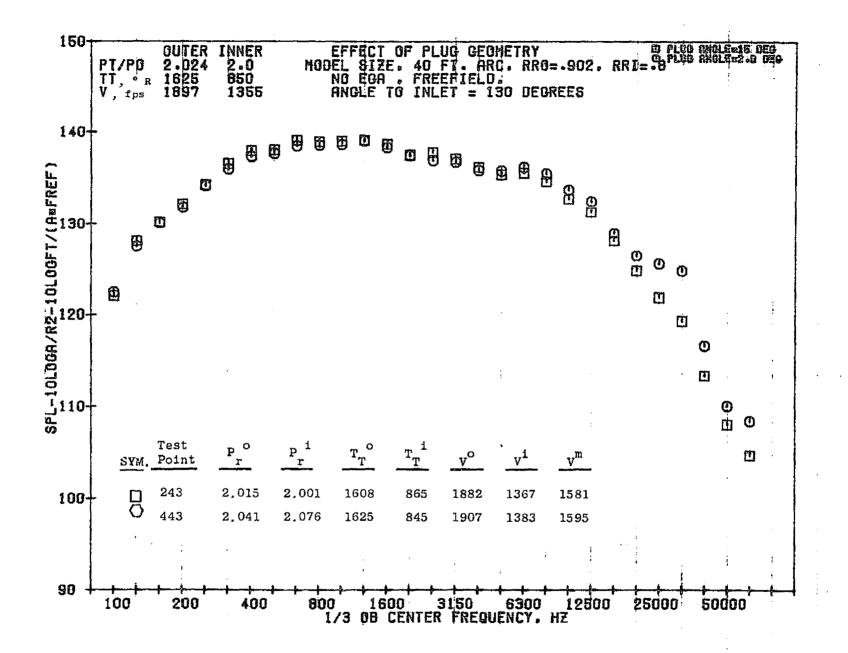




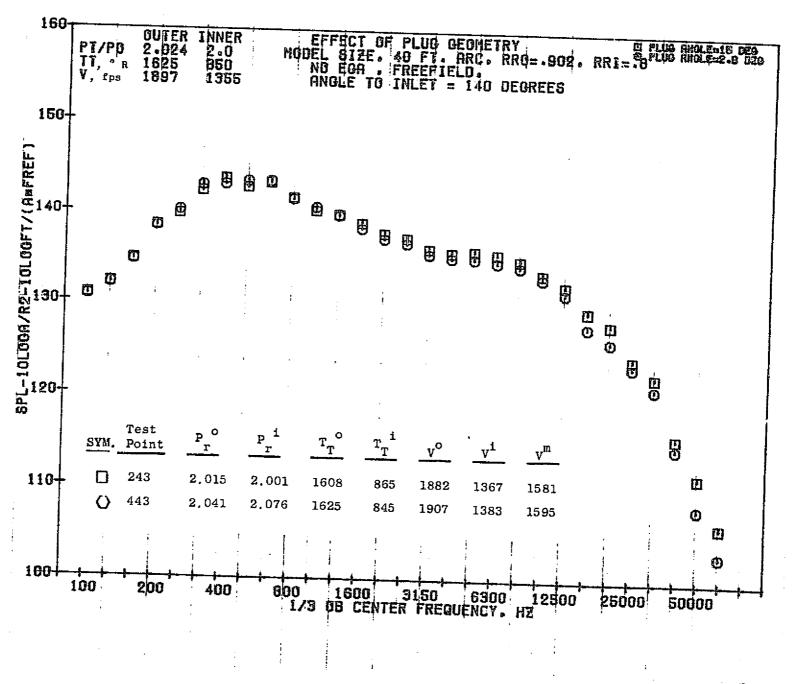


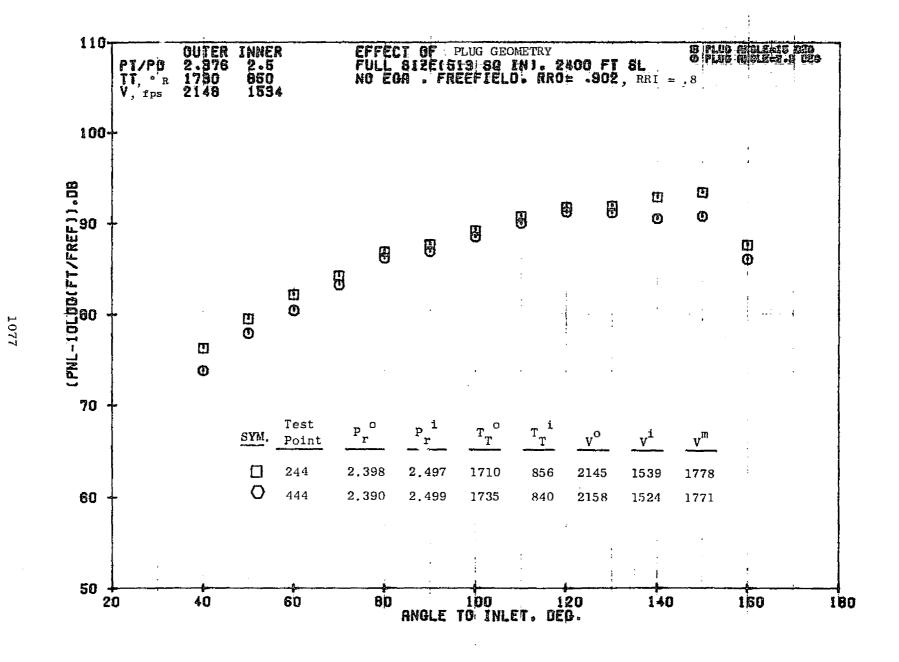
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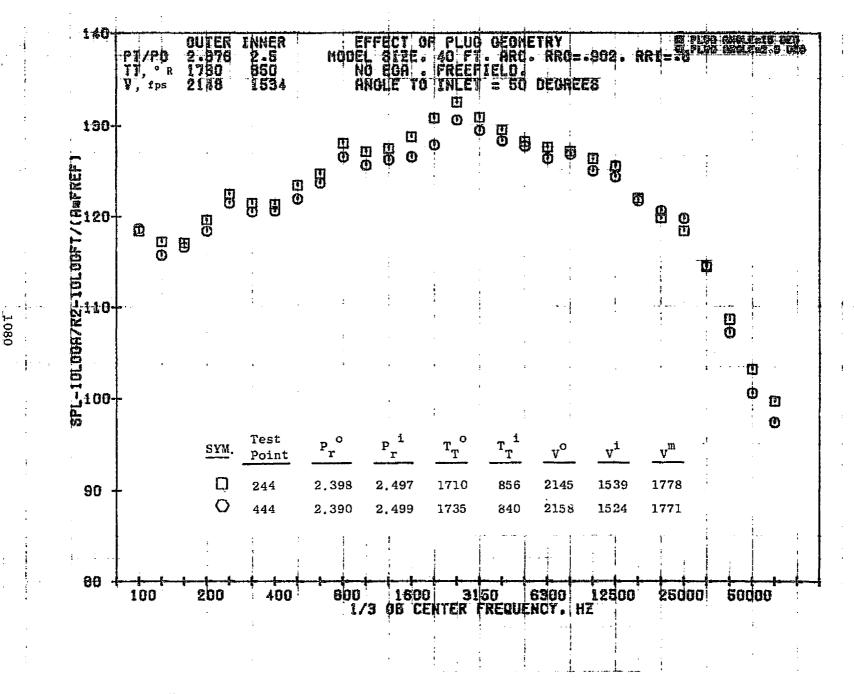


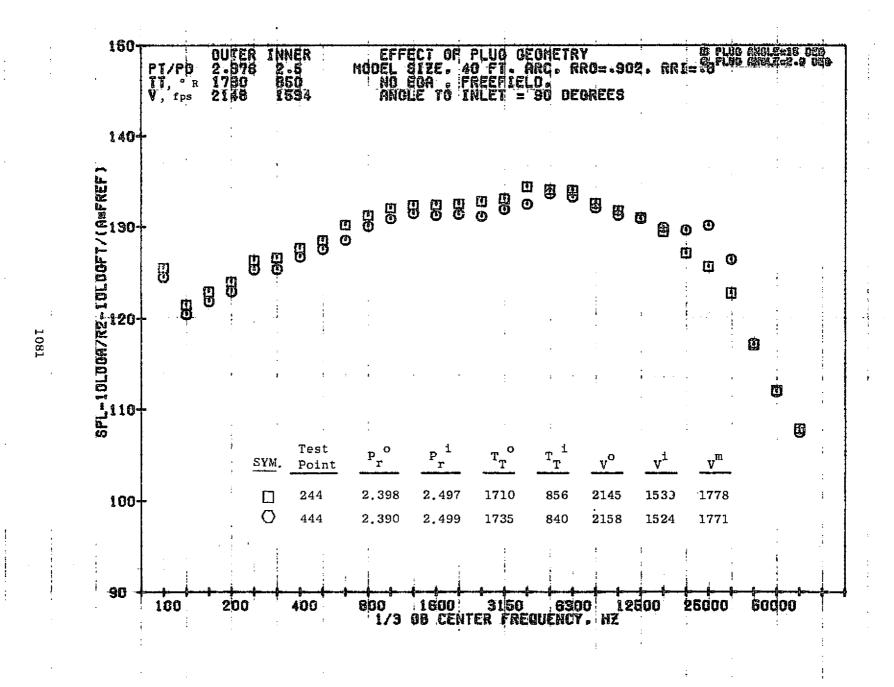


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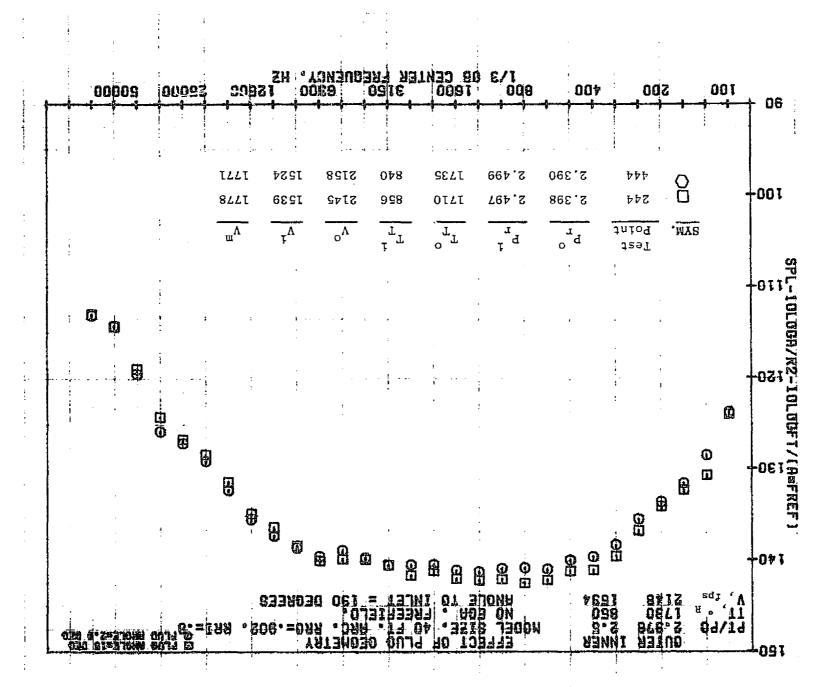
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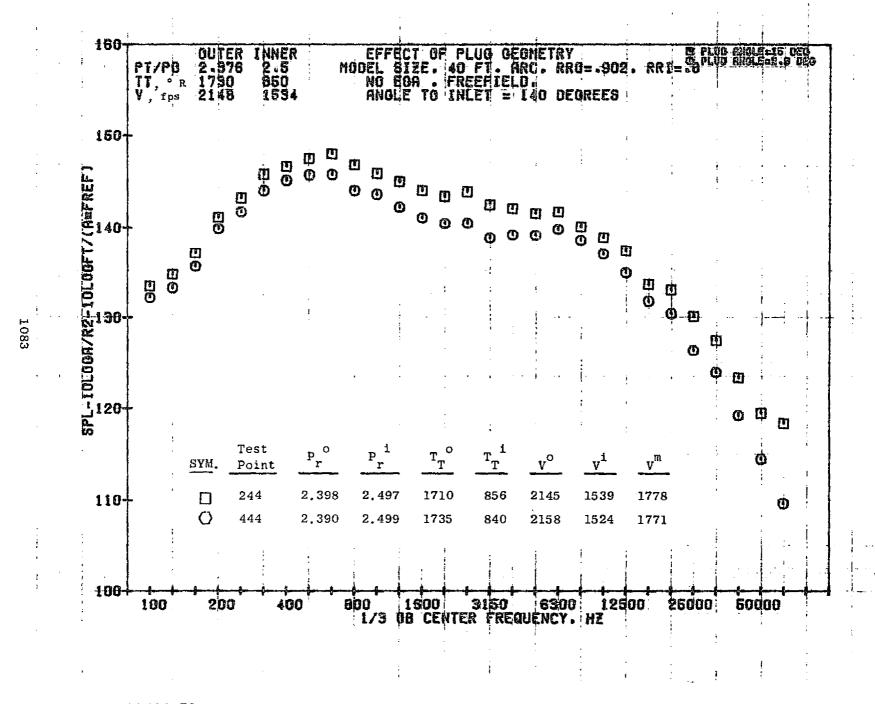




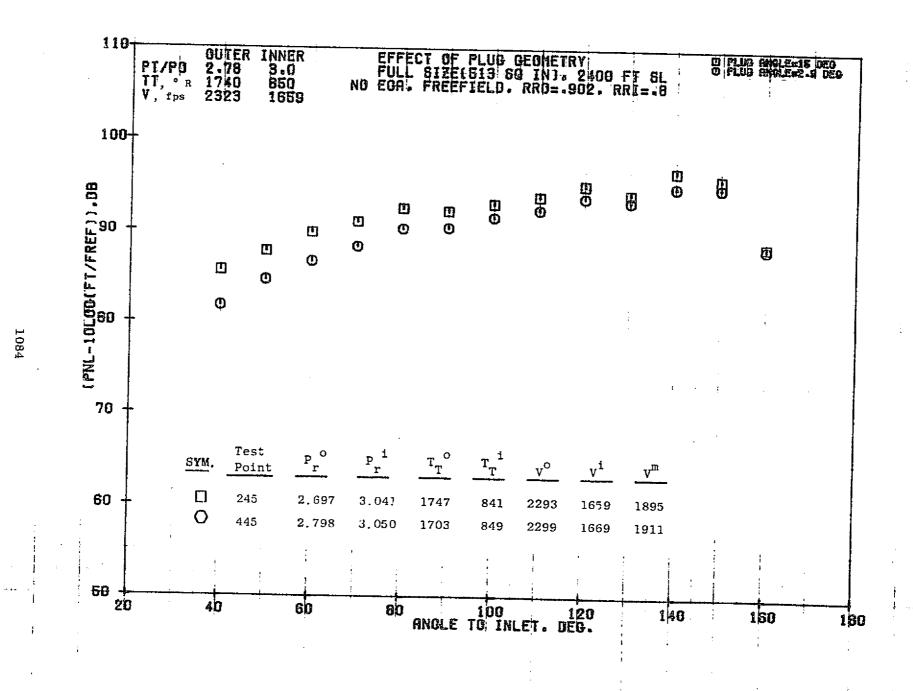
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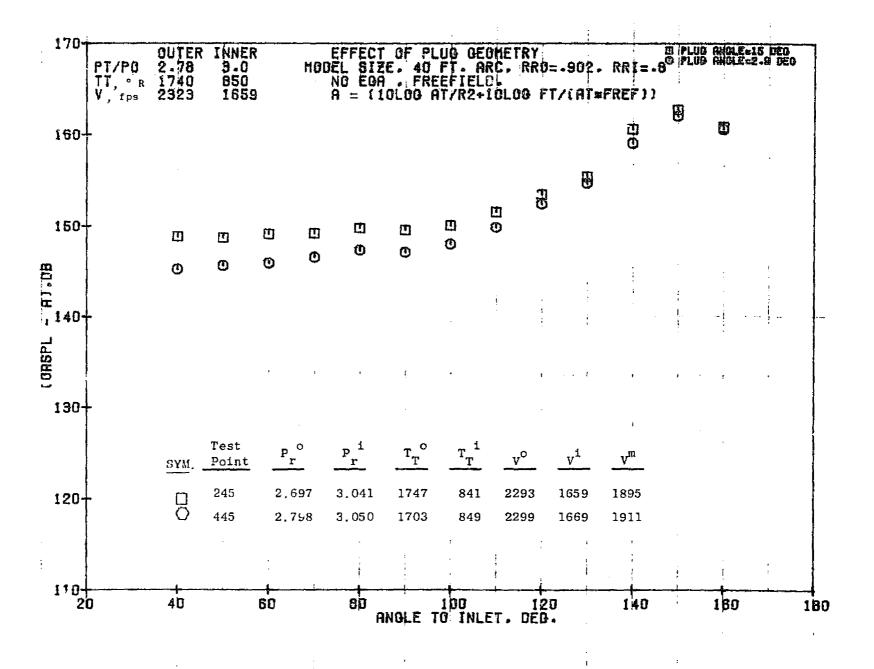




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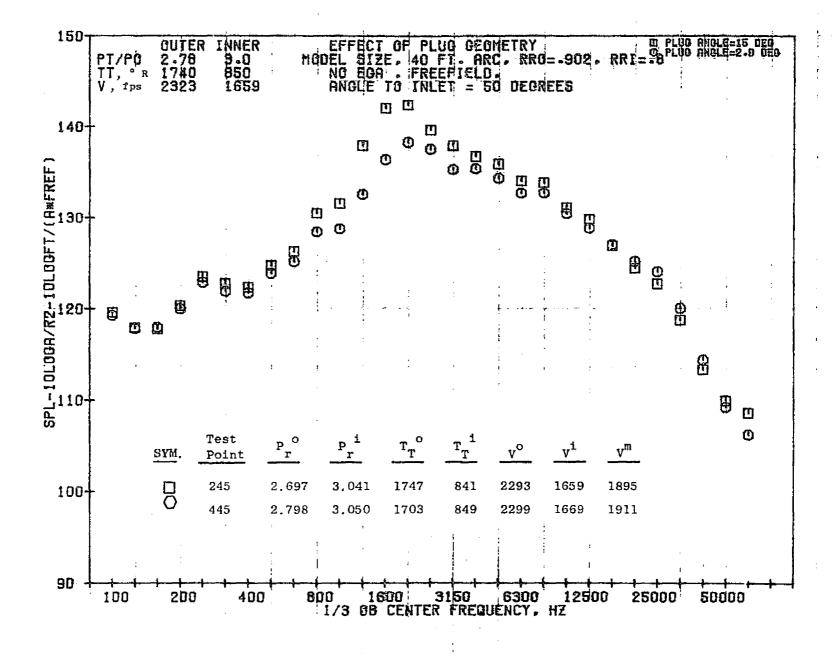
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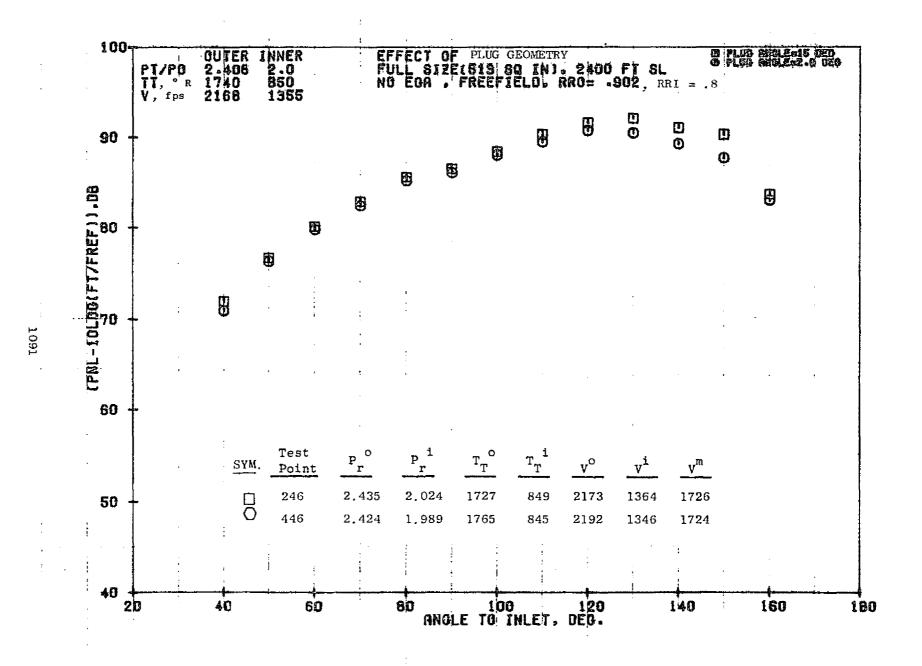
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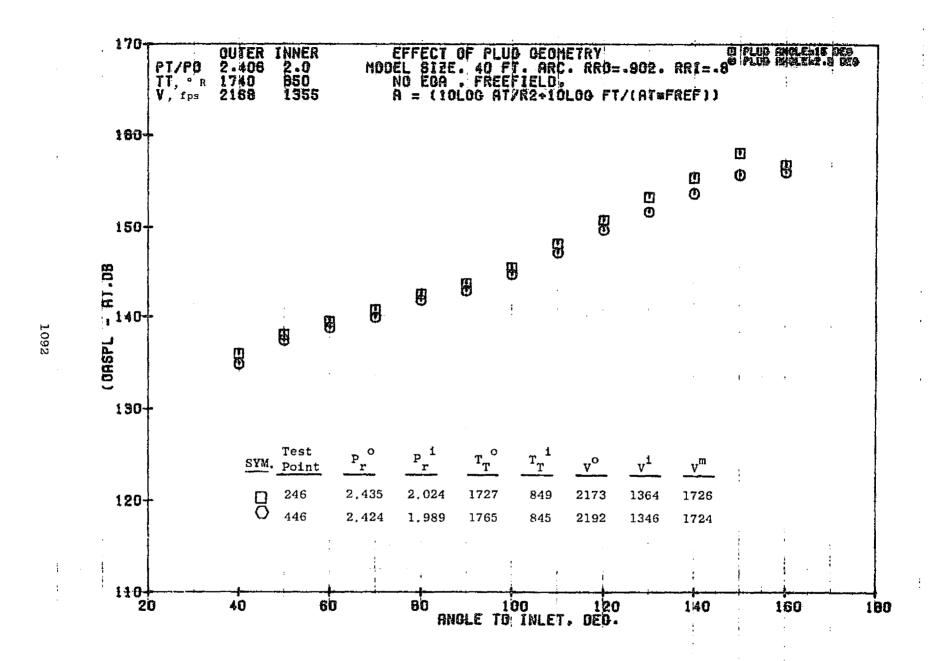


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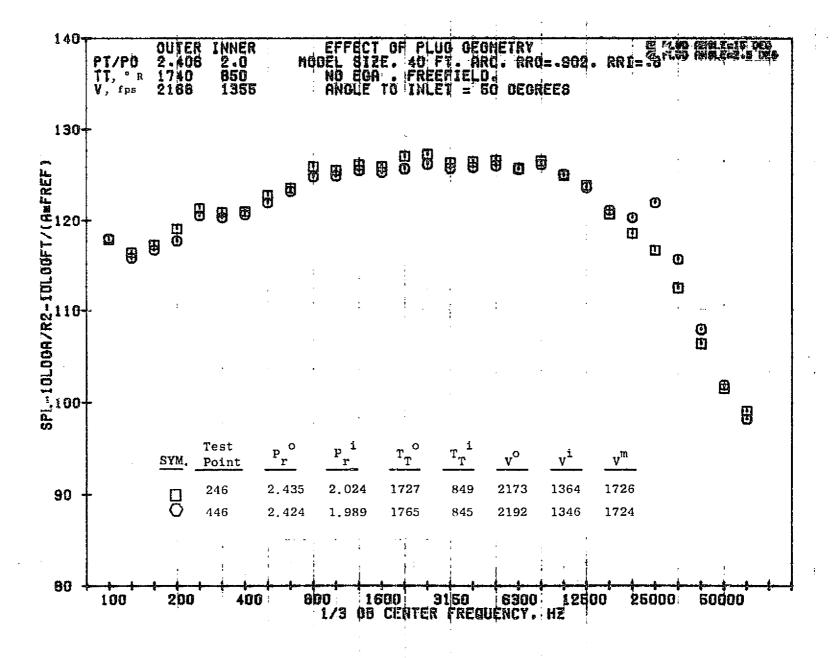
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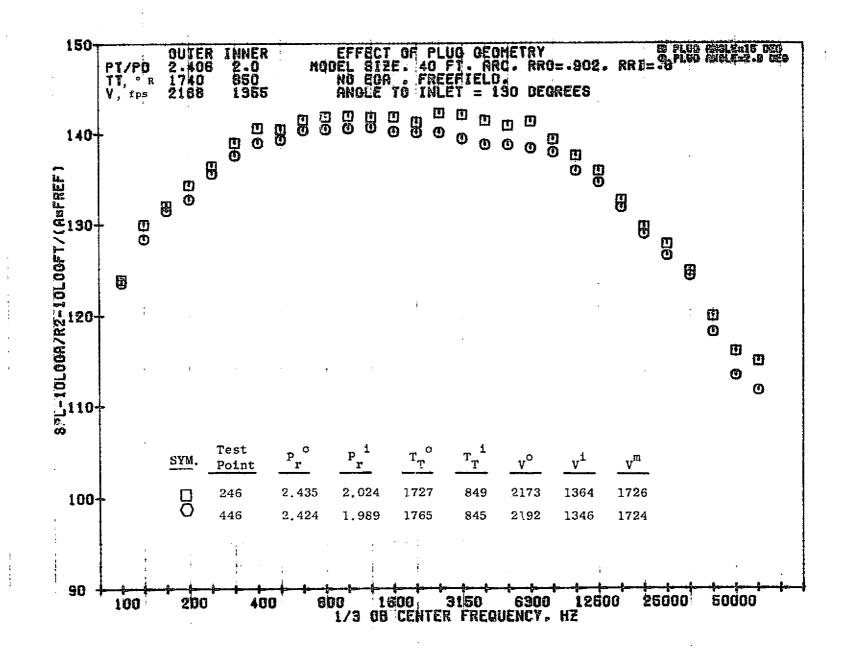
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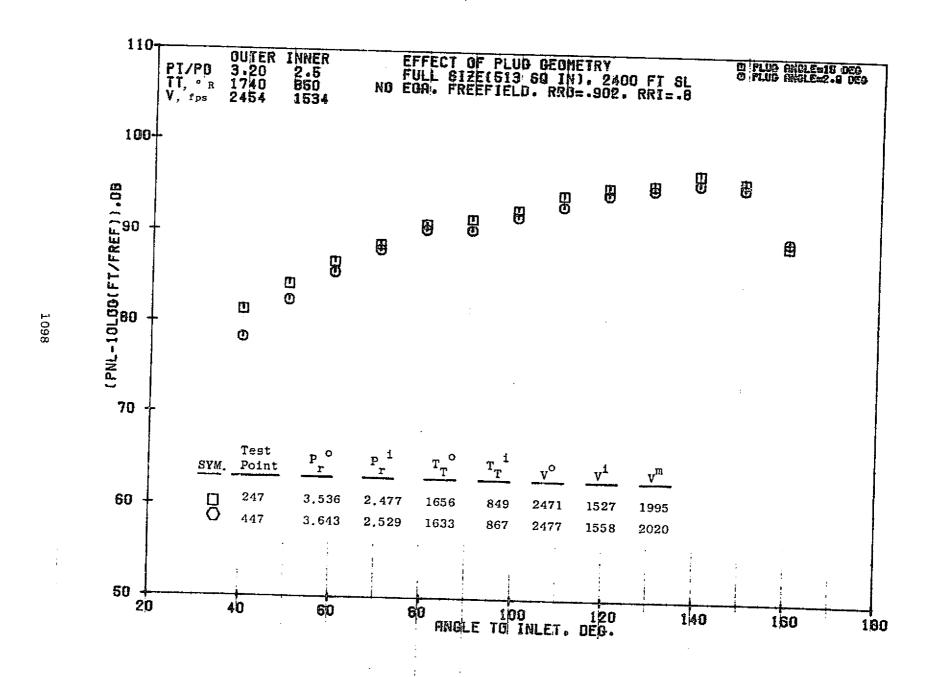




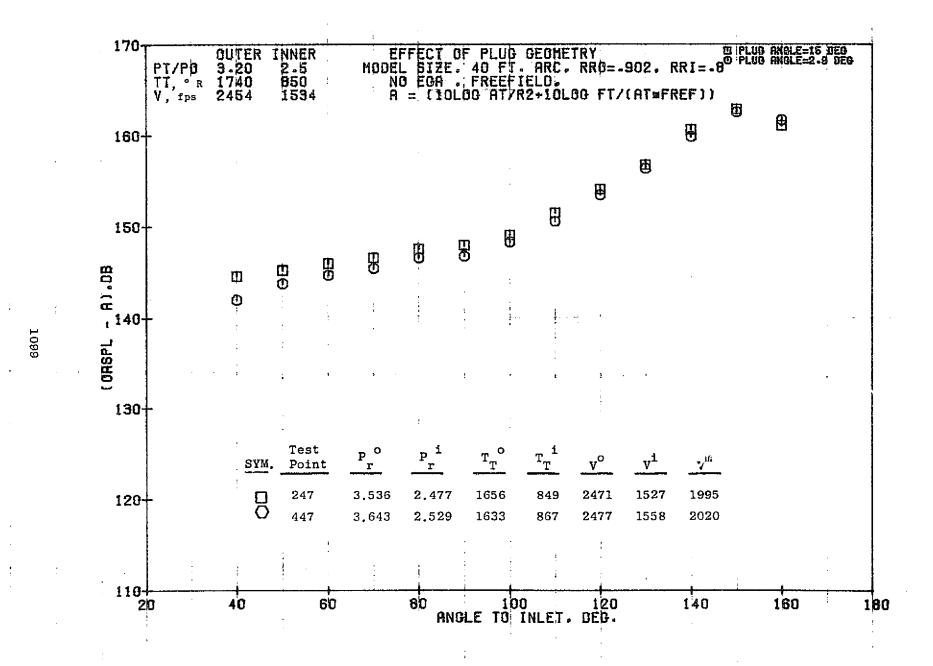


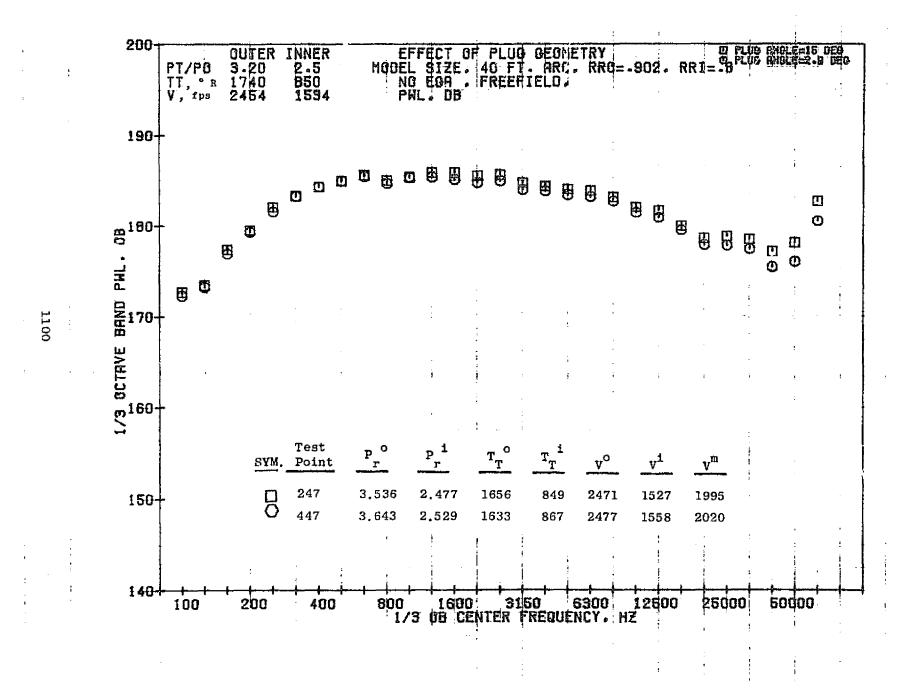
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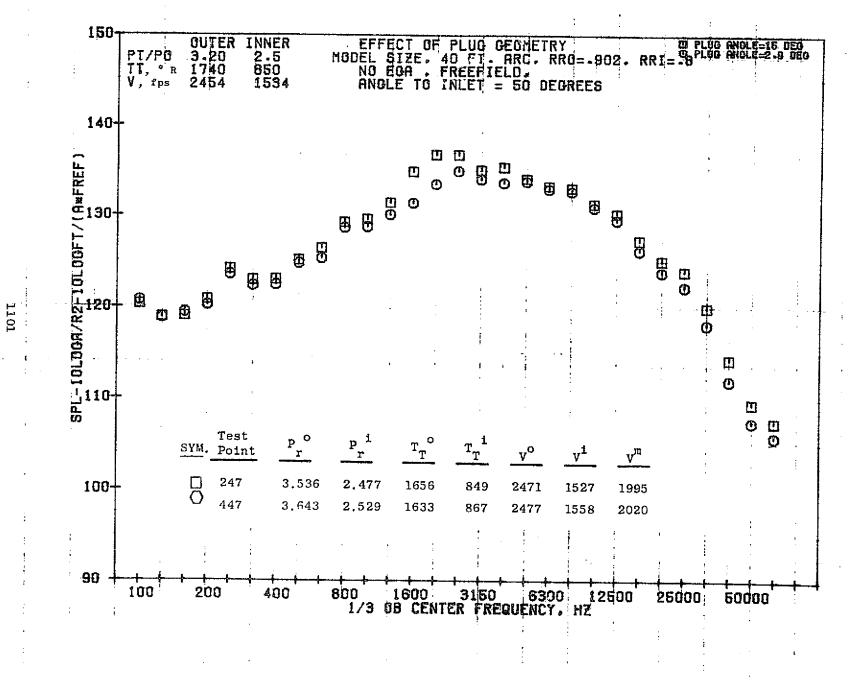
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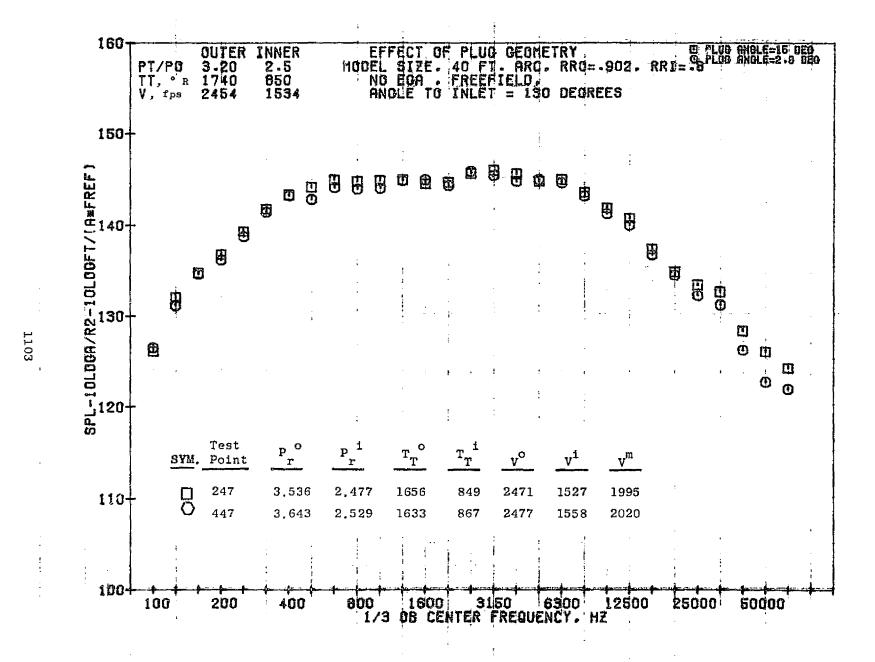
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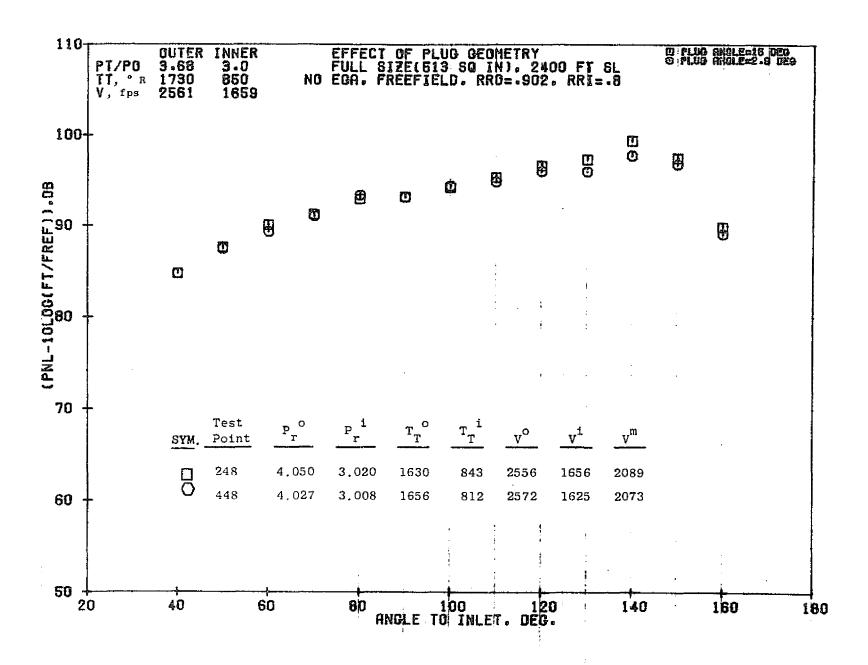


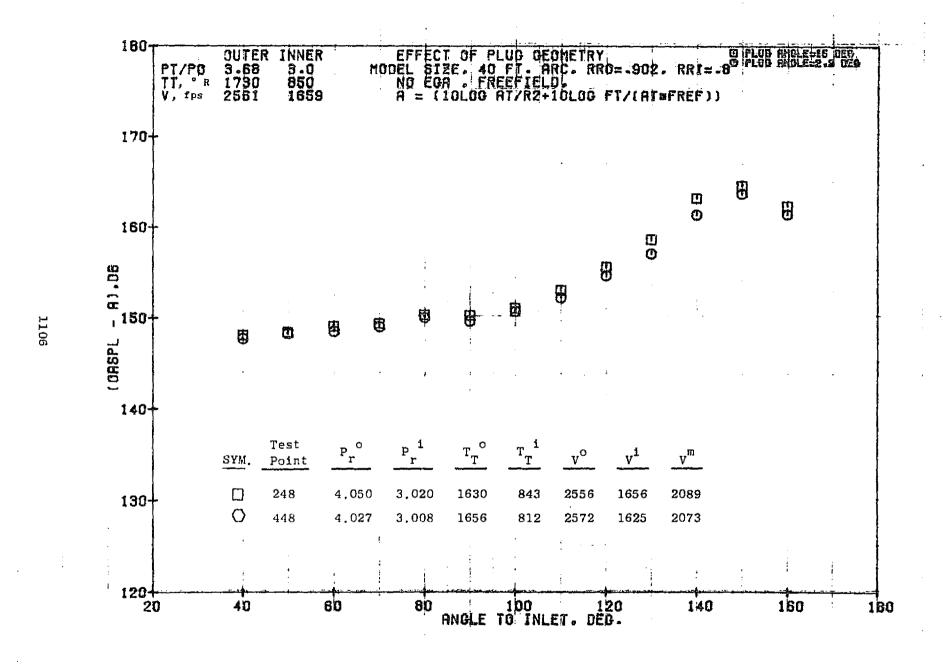


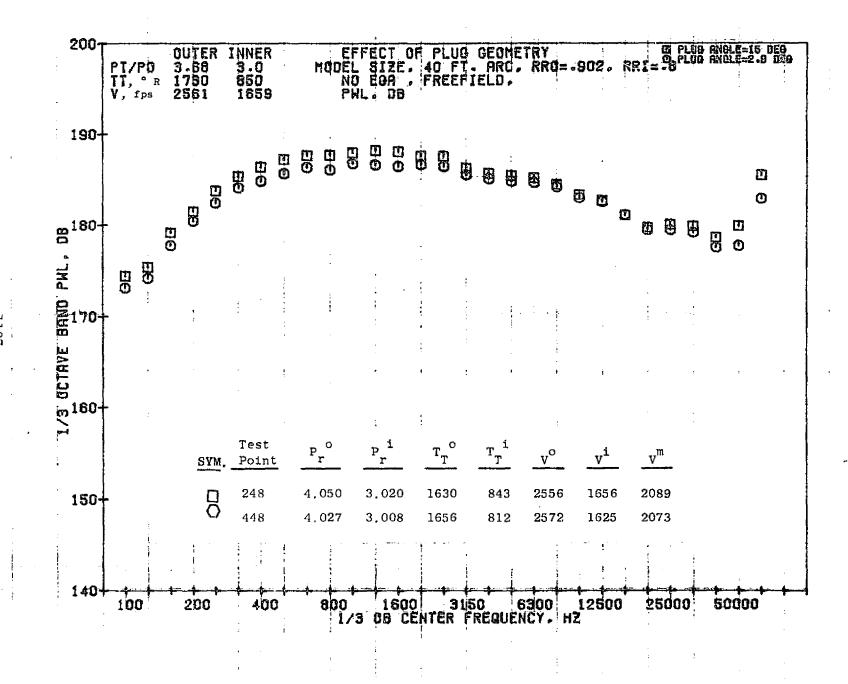
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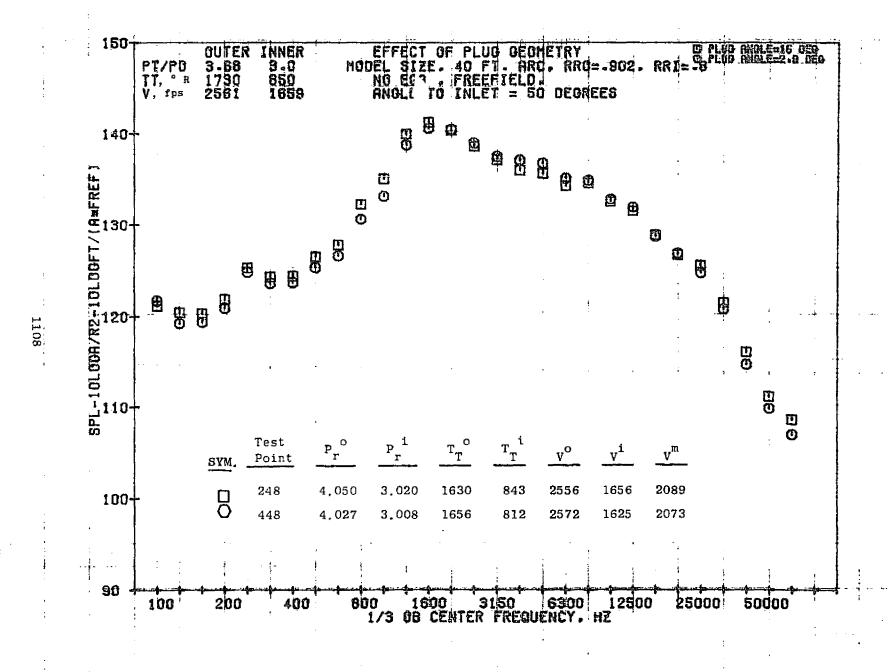
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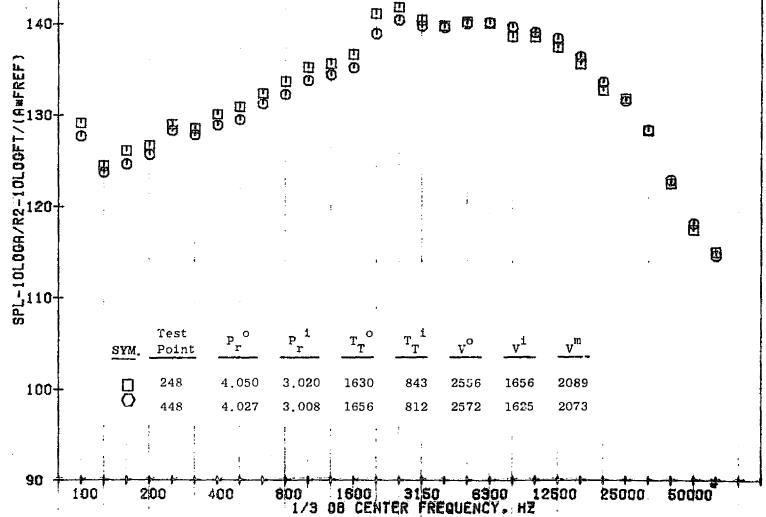






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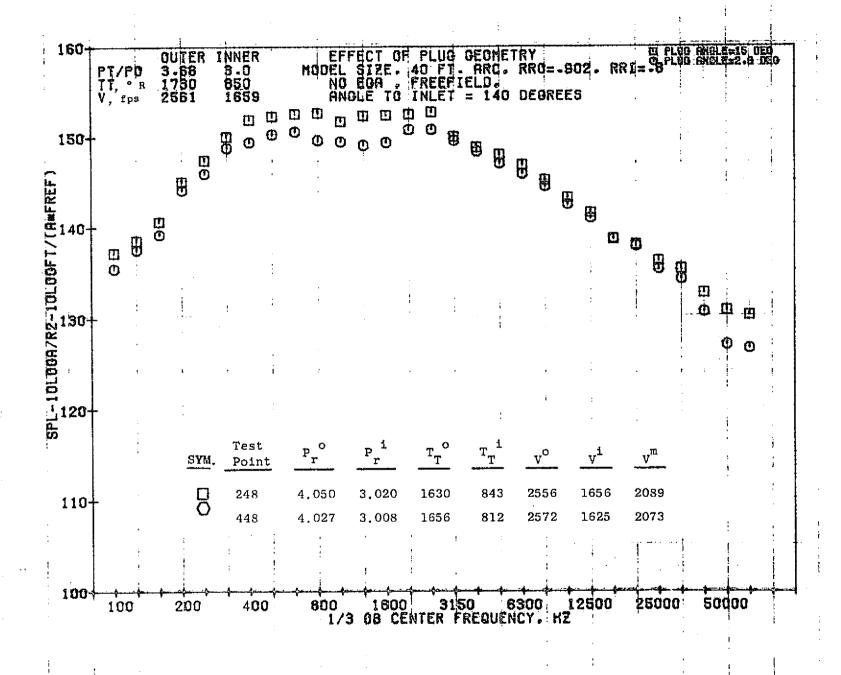


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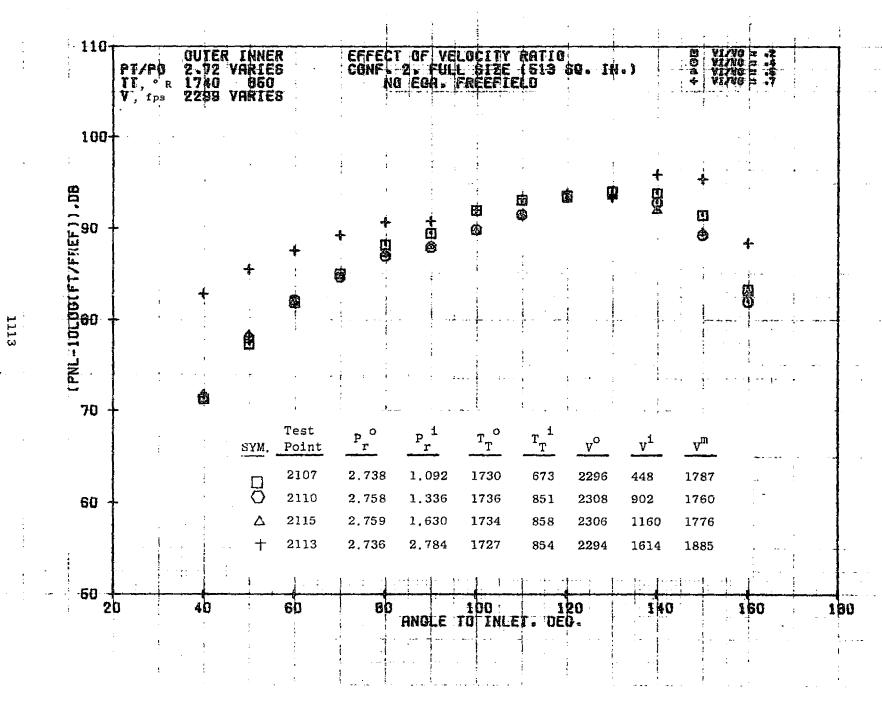
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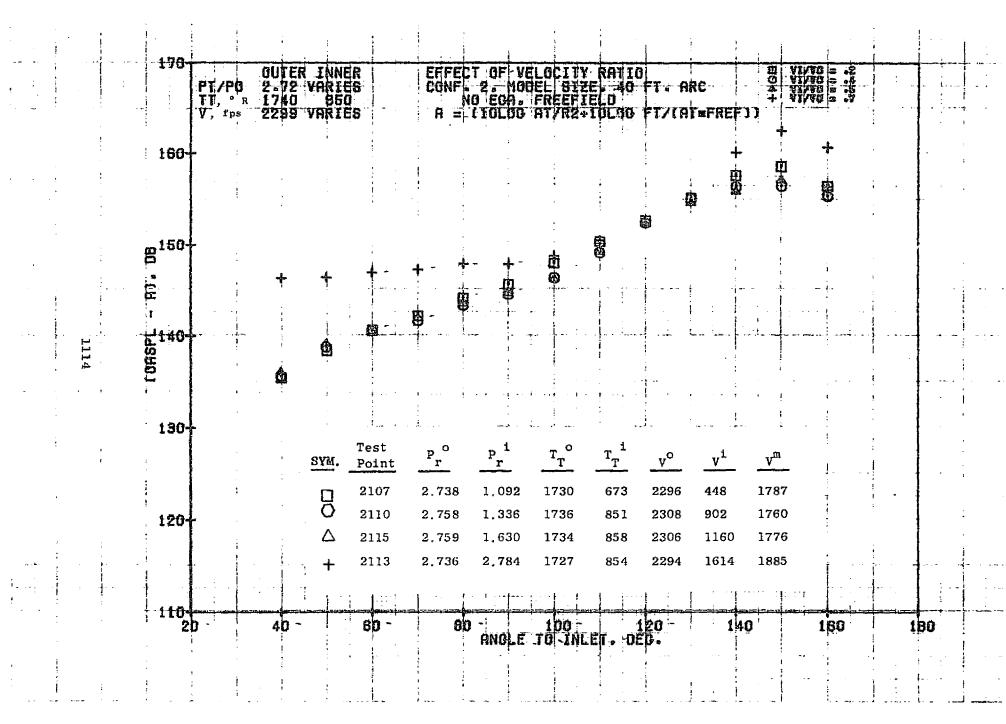
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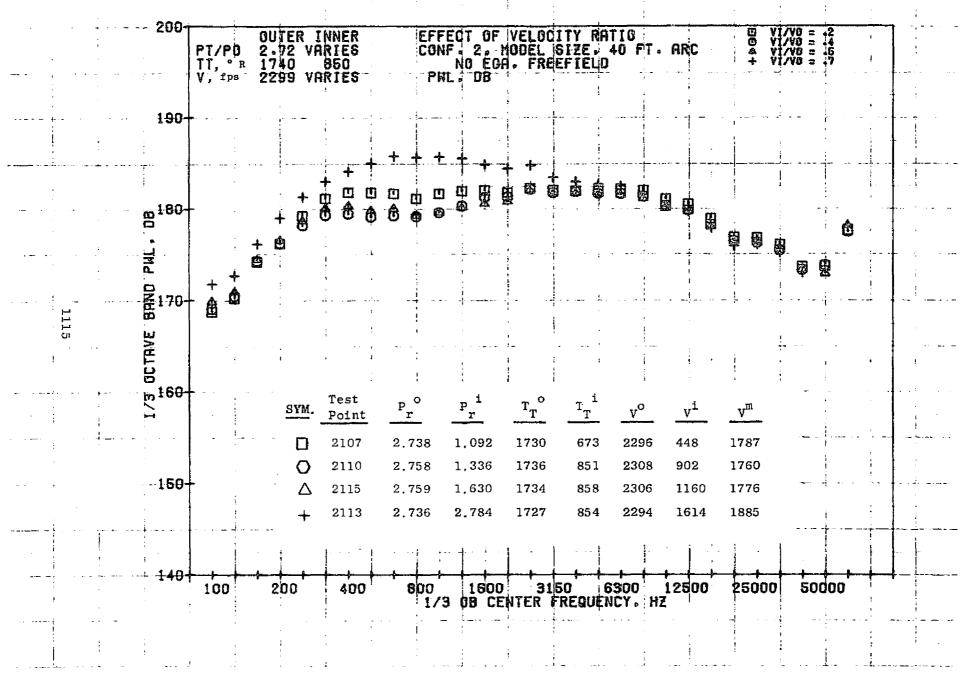
7.4.4. Effect of Velocity Ratio

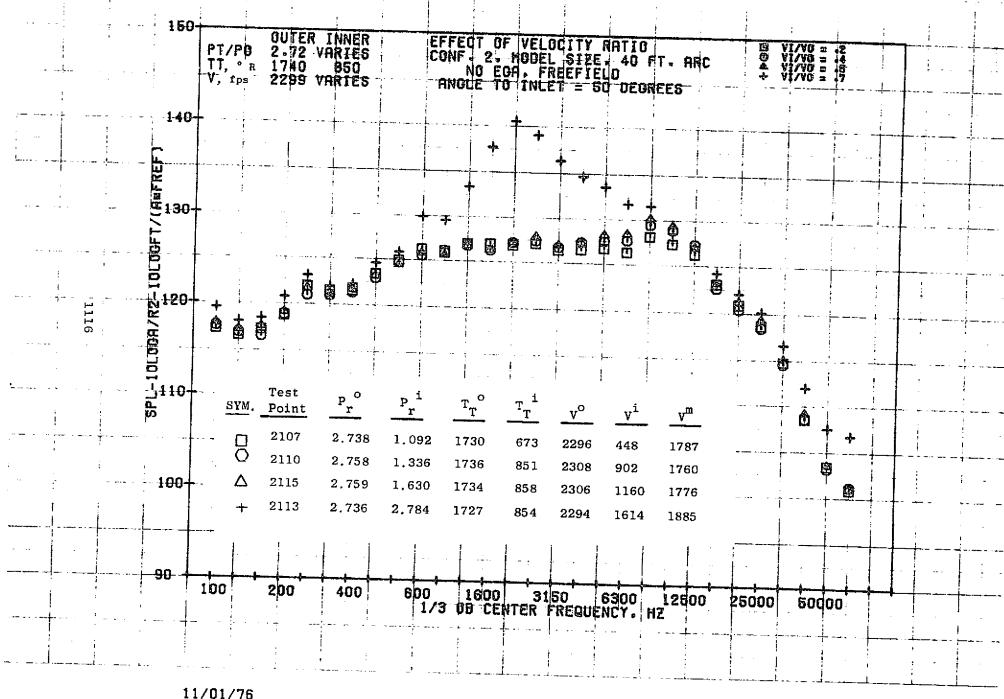
For Configurations 2 through 7, test points were run with the outer stream aerodynamic parameters held constant while the inner stream velocity was varied to determine the effect of velocity ratio. The results are shown in this section.



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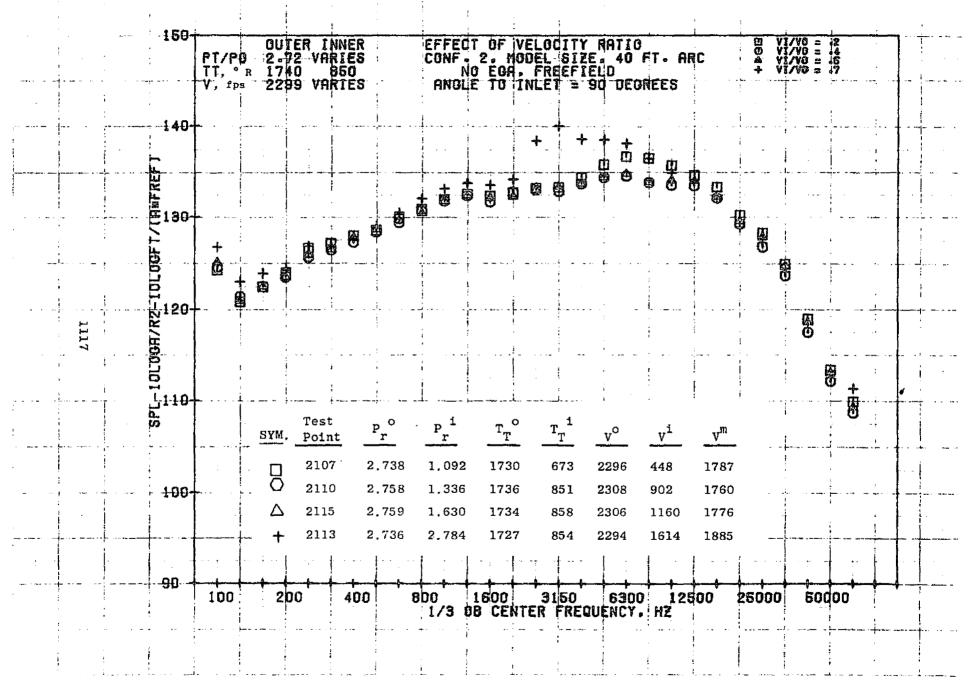


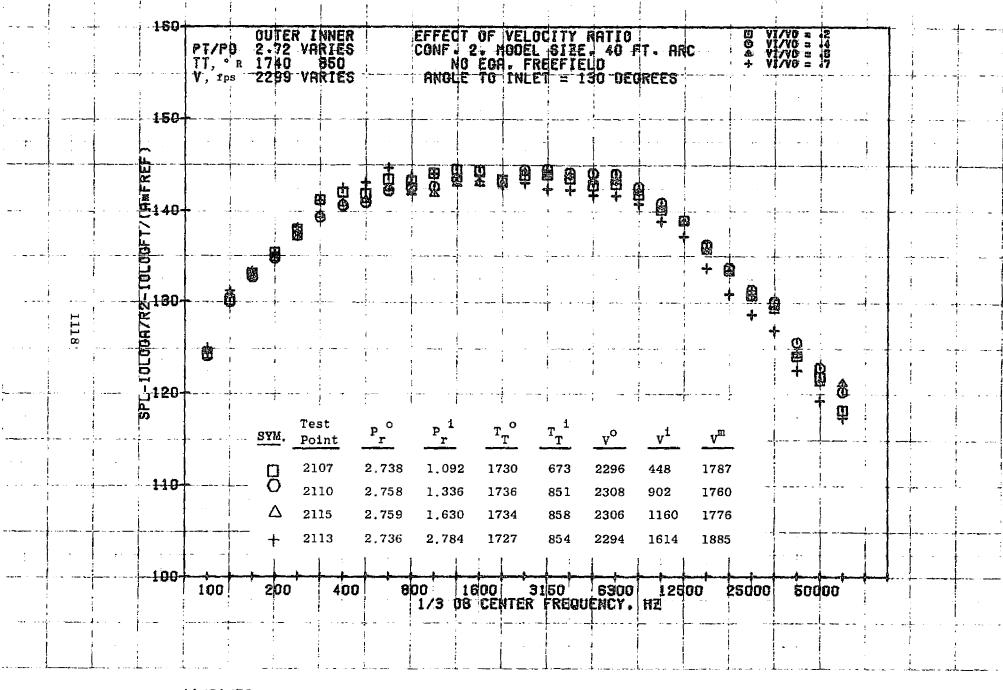




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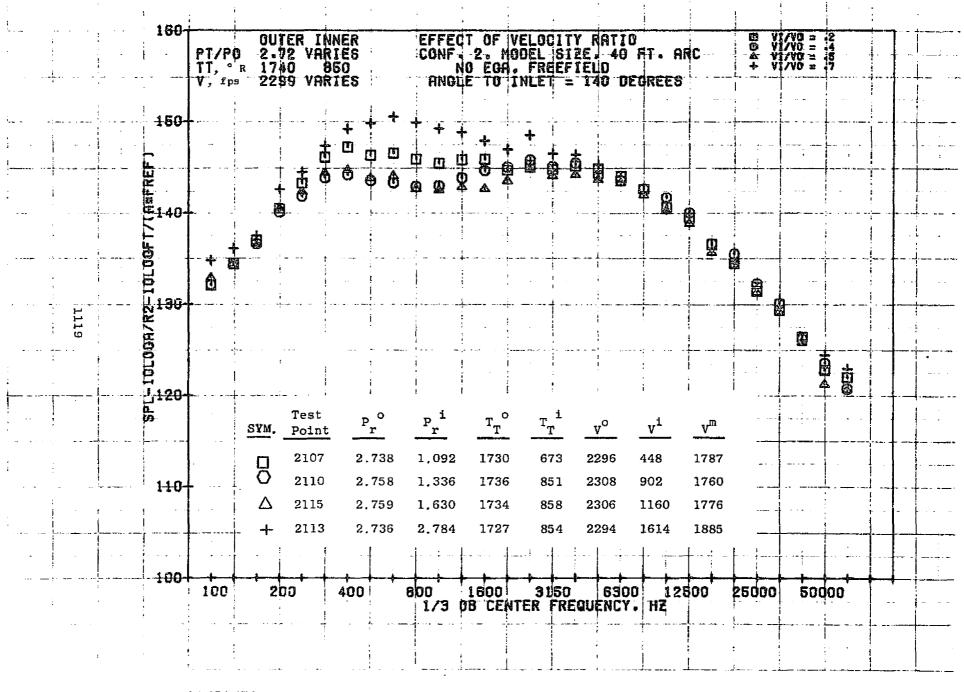
79 BURCH A.

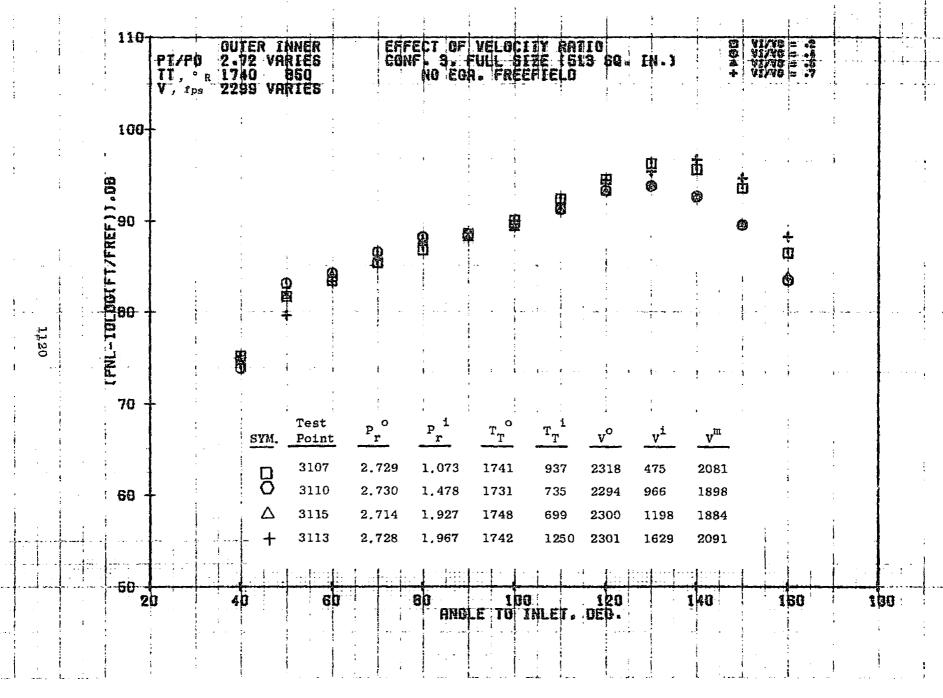




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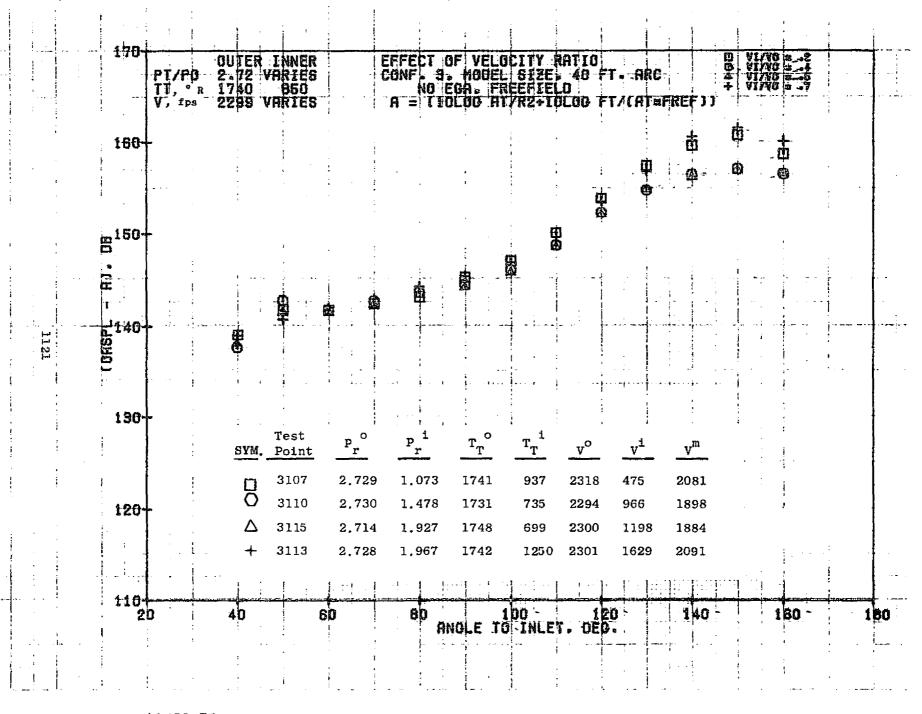
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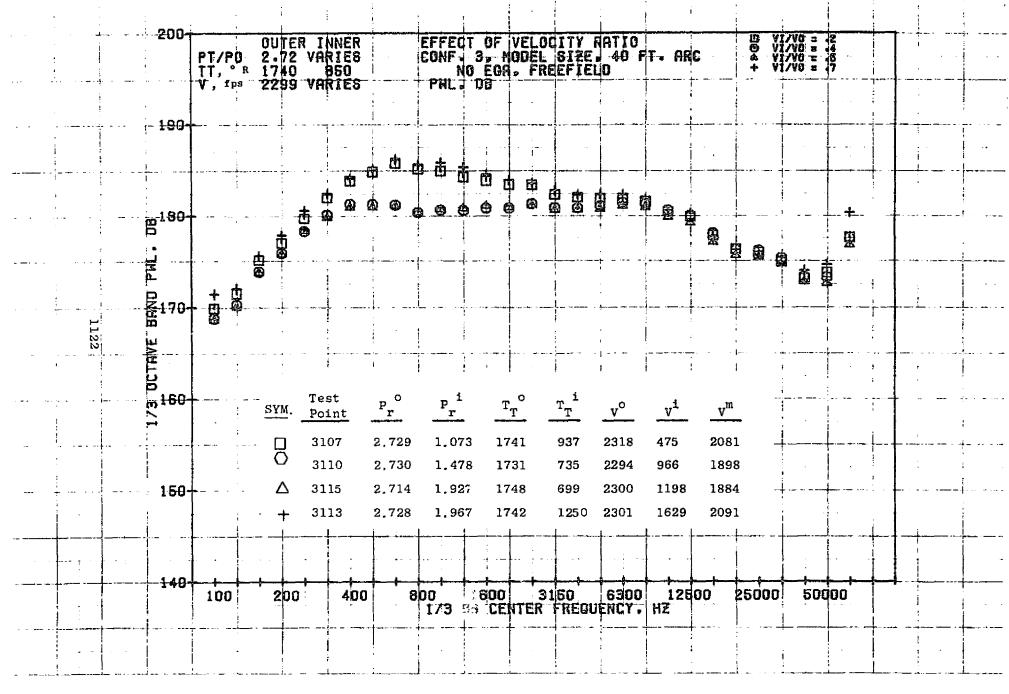


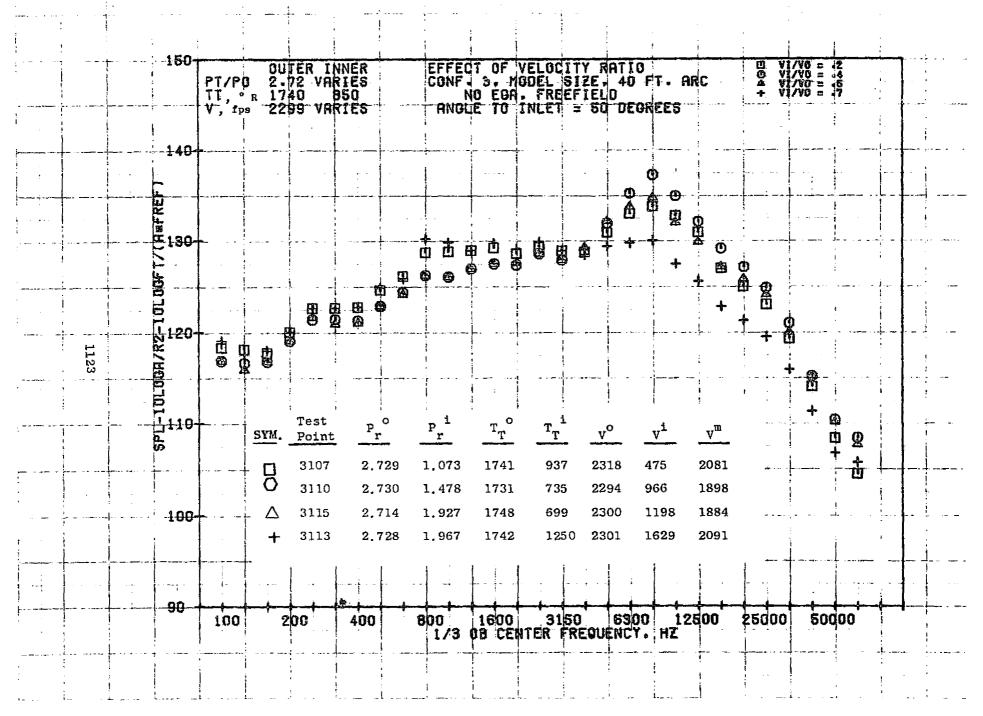


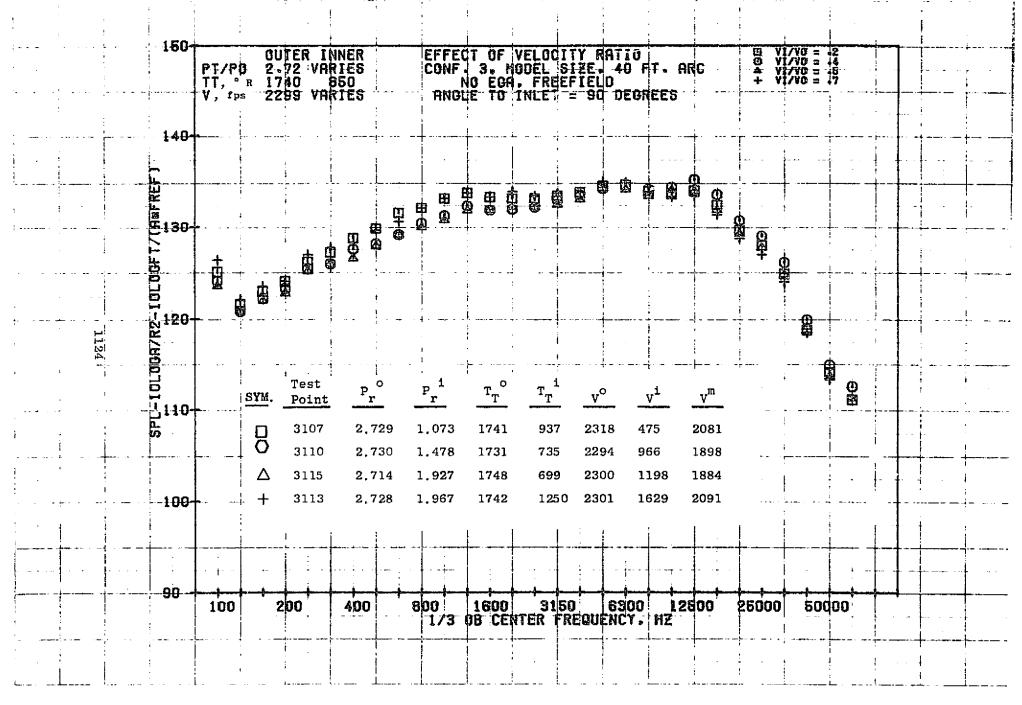
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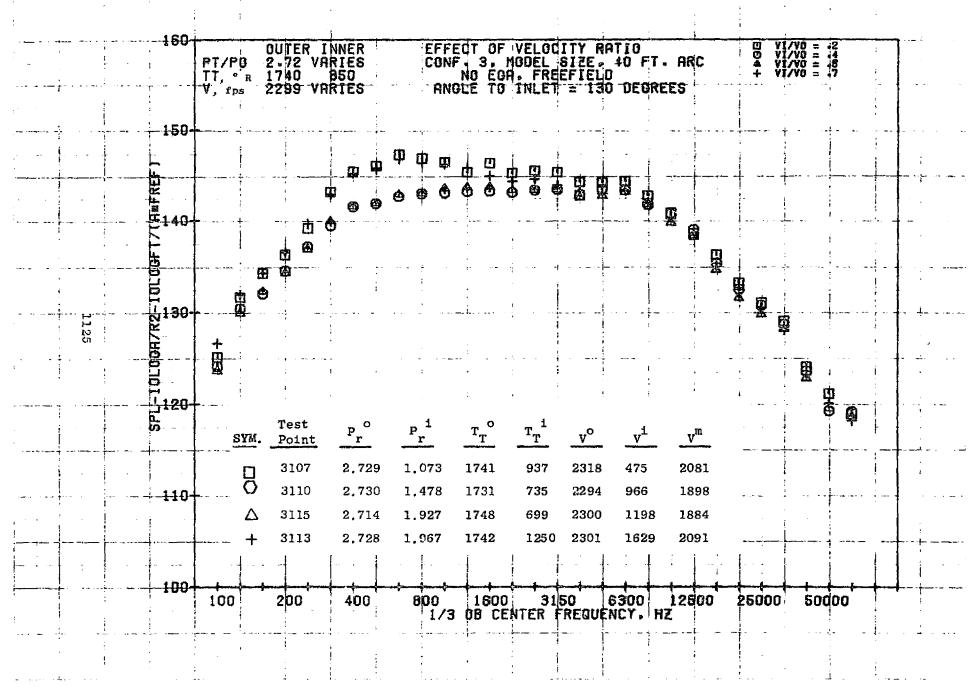
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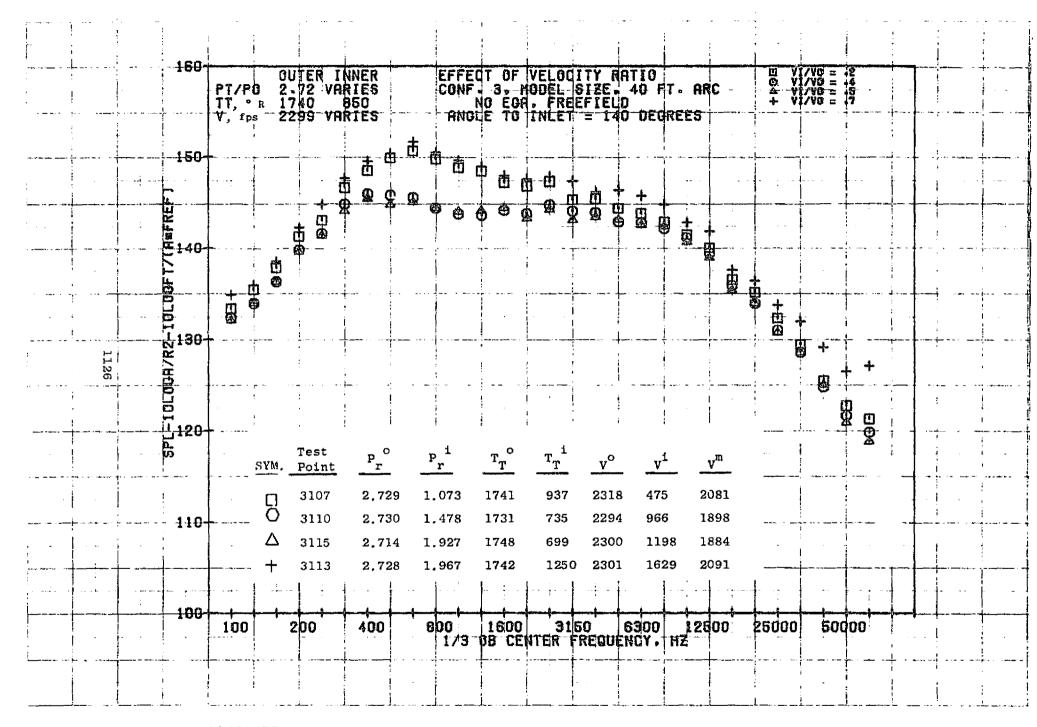




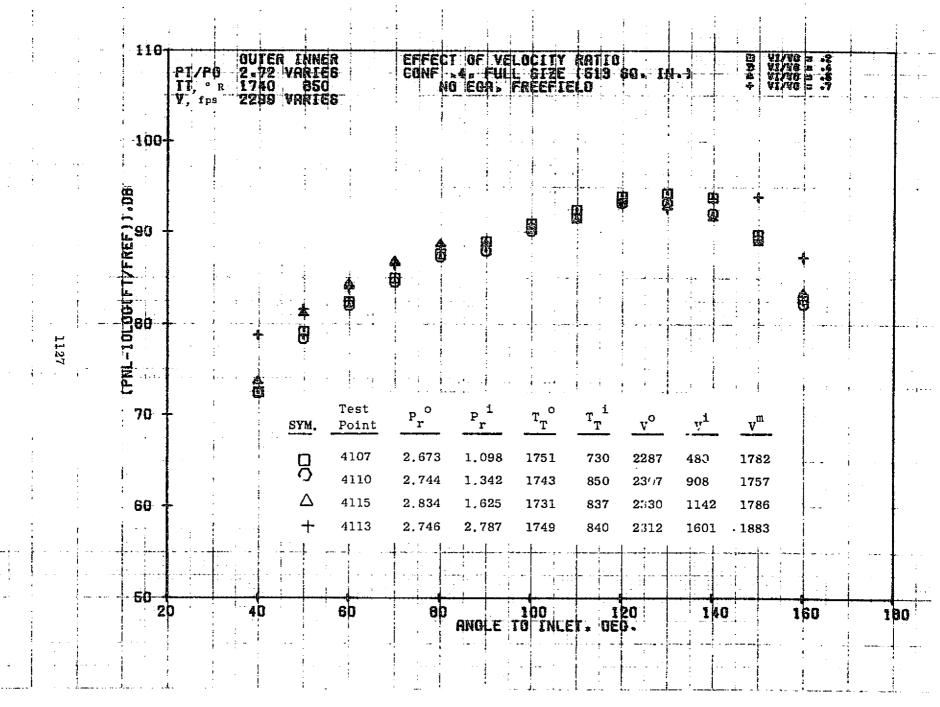




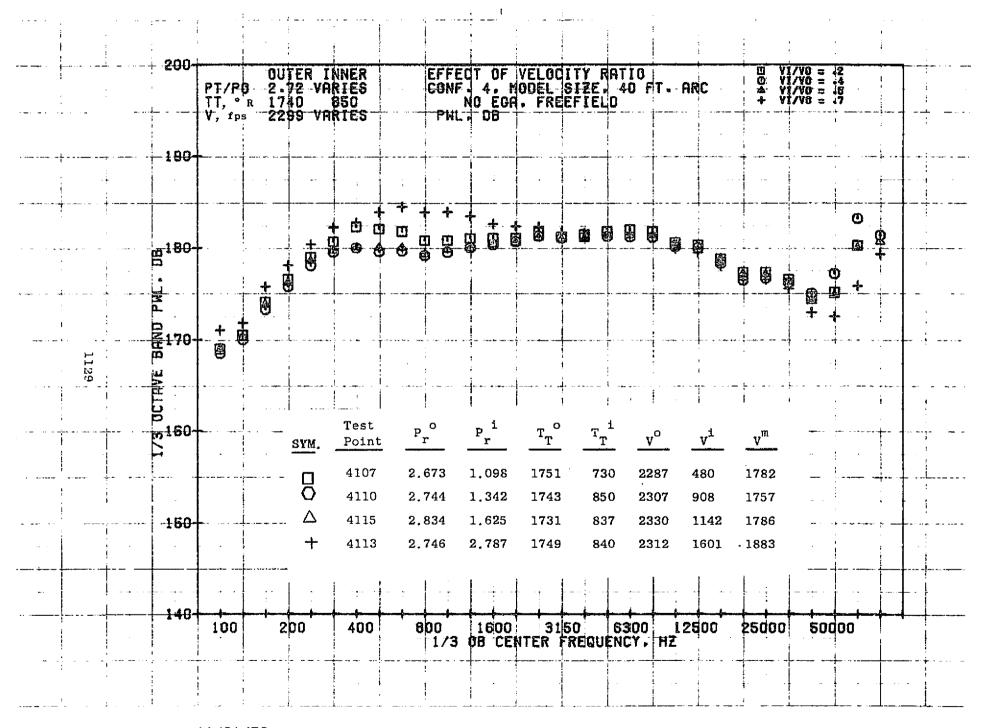




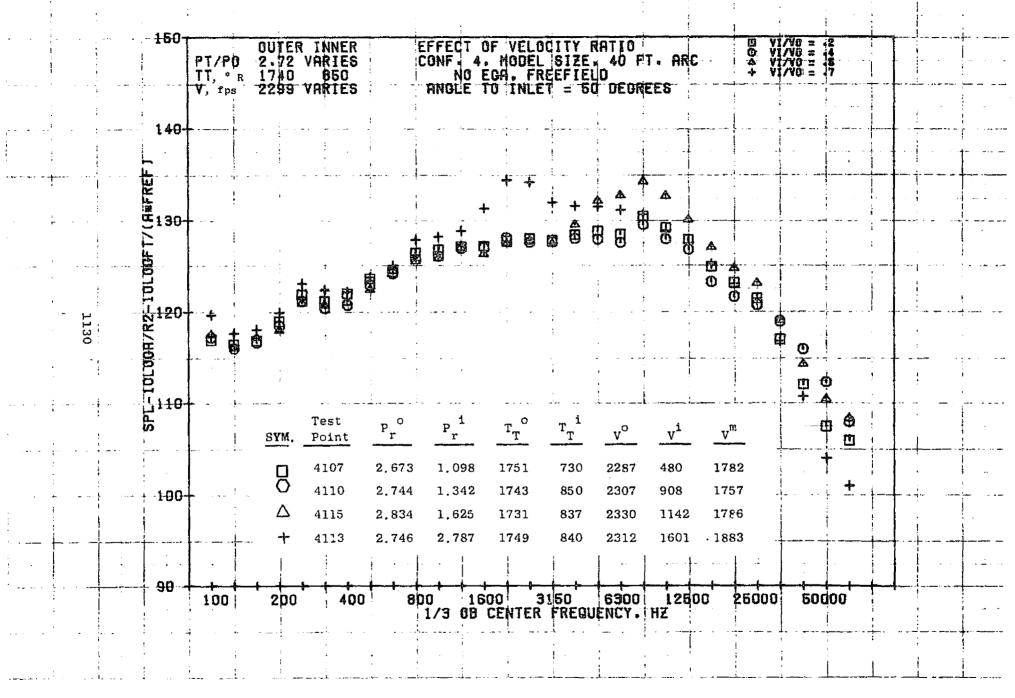
建筑作品的实验证 (1) 表示证

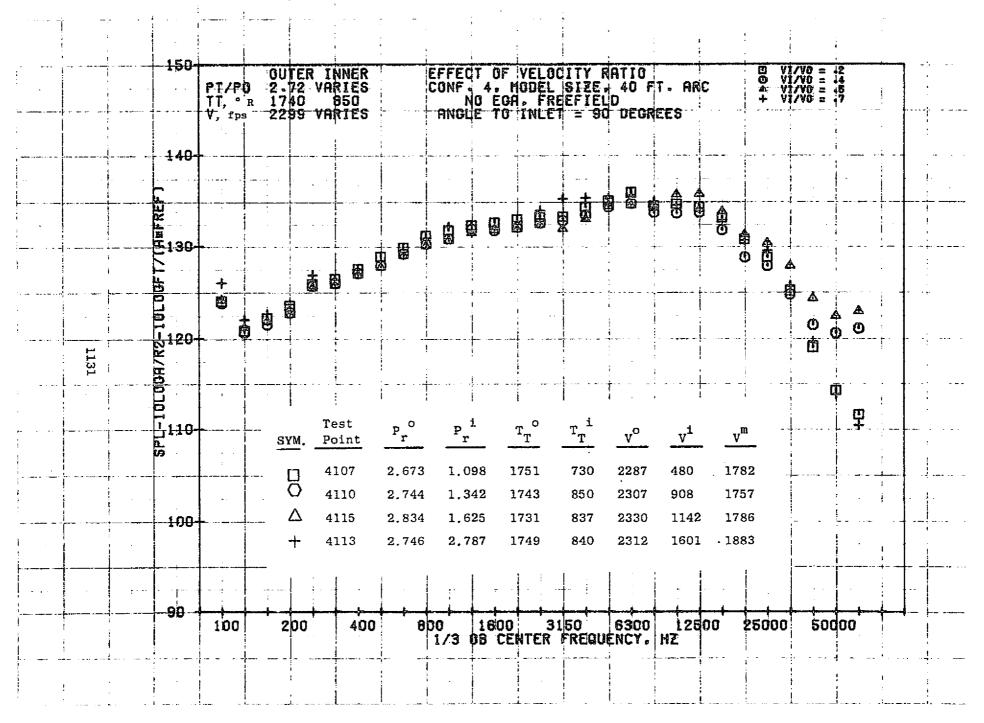


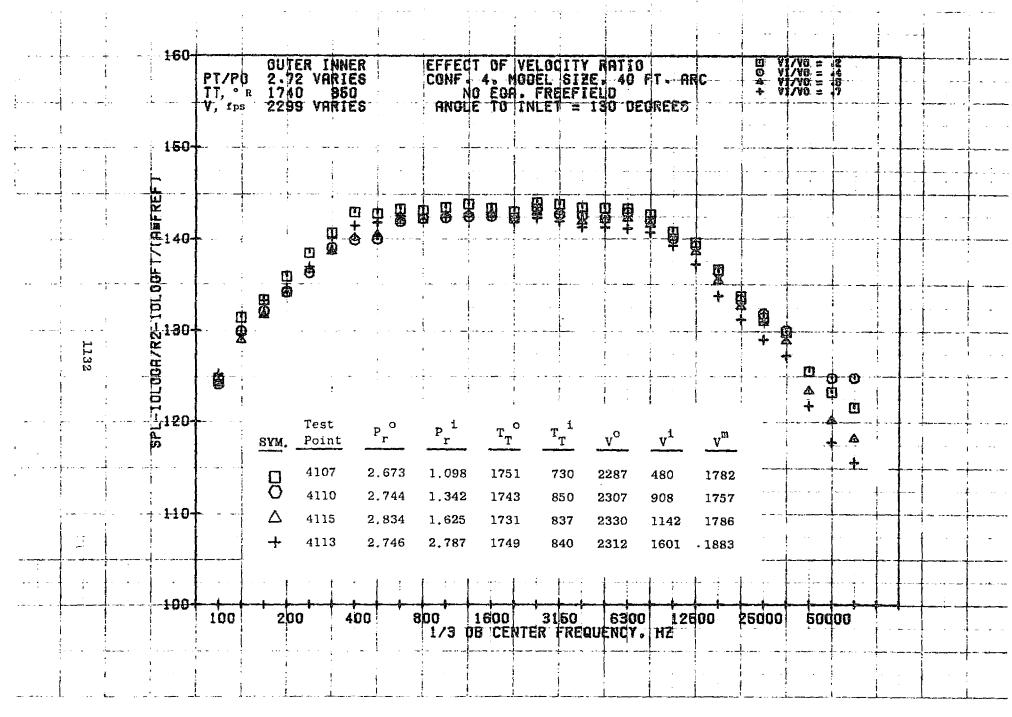
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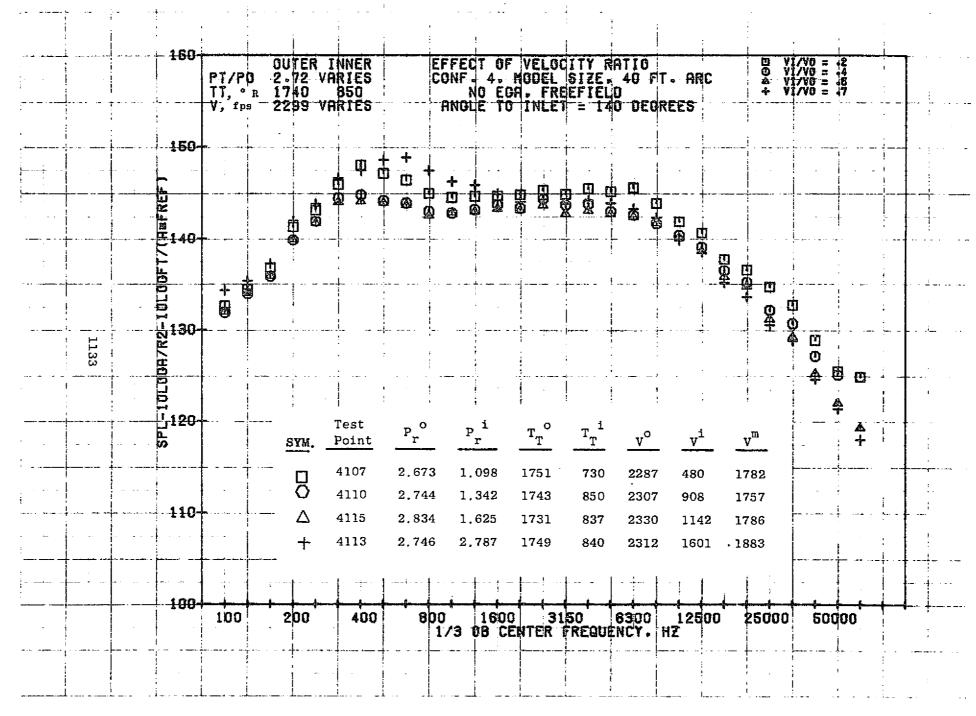


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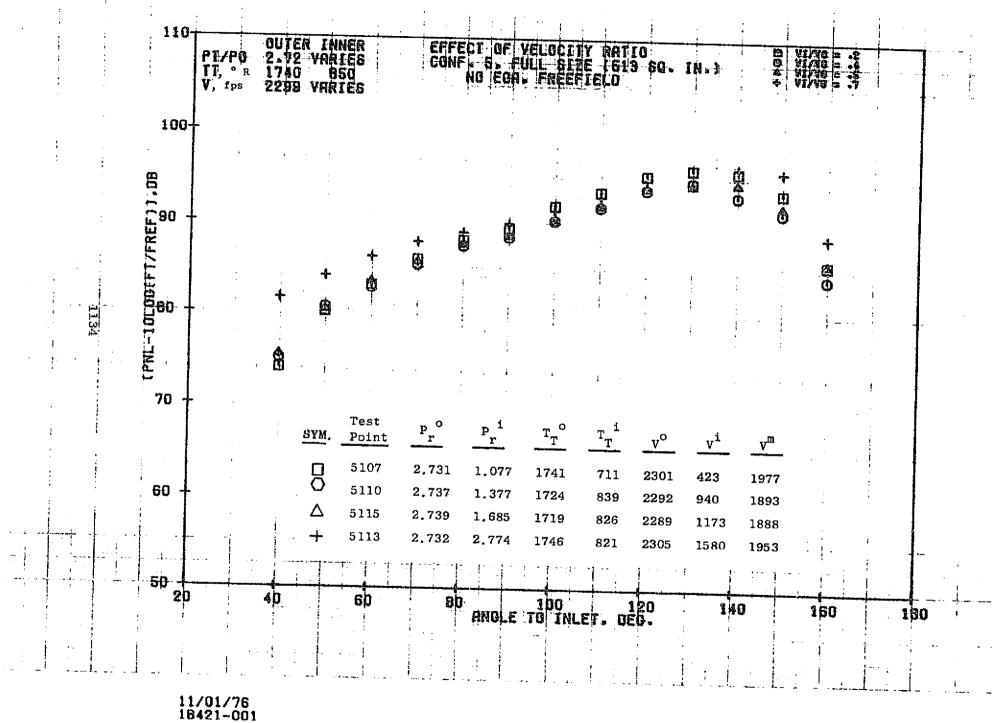








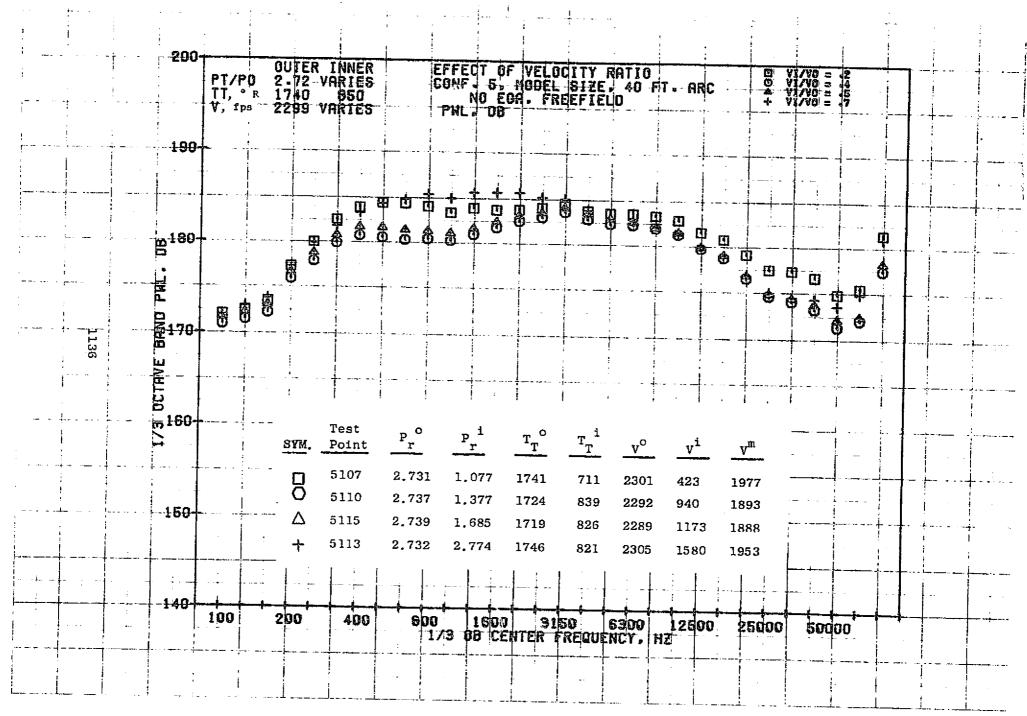
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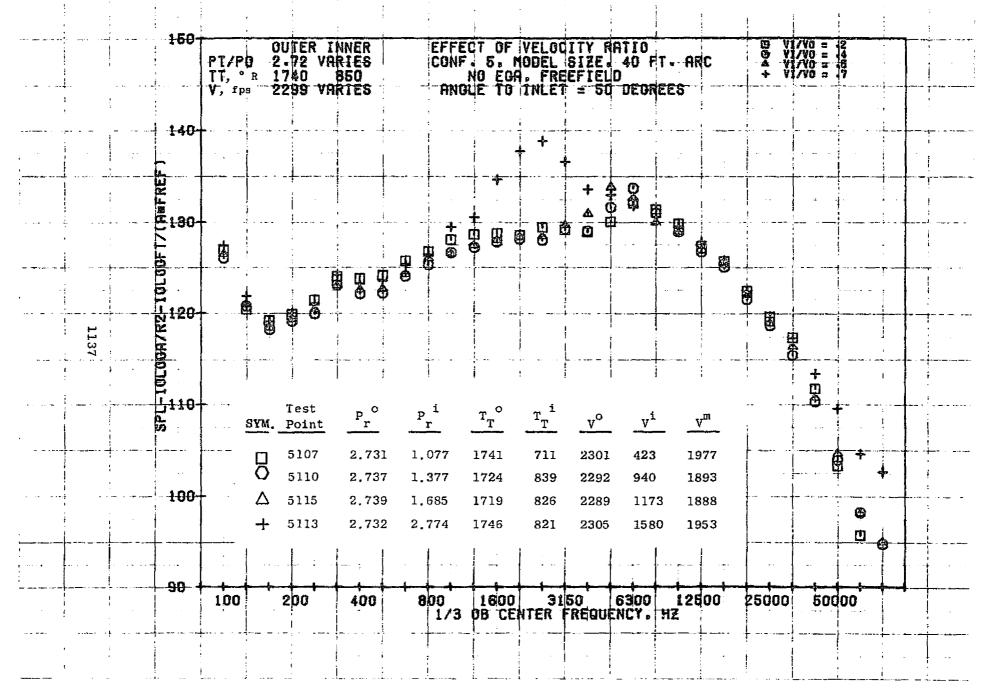
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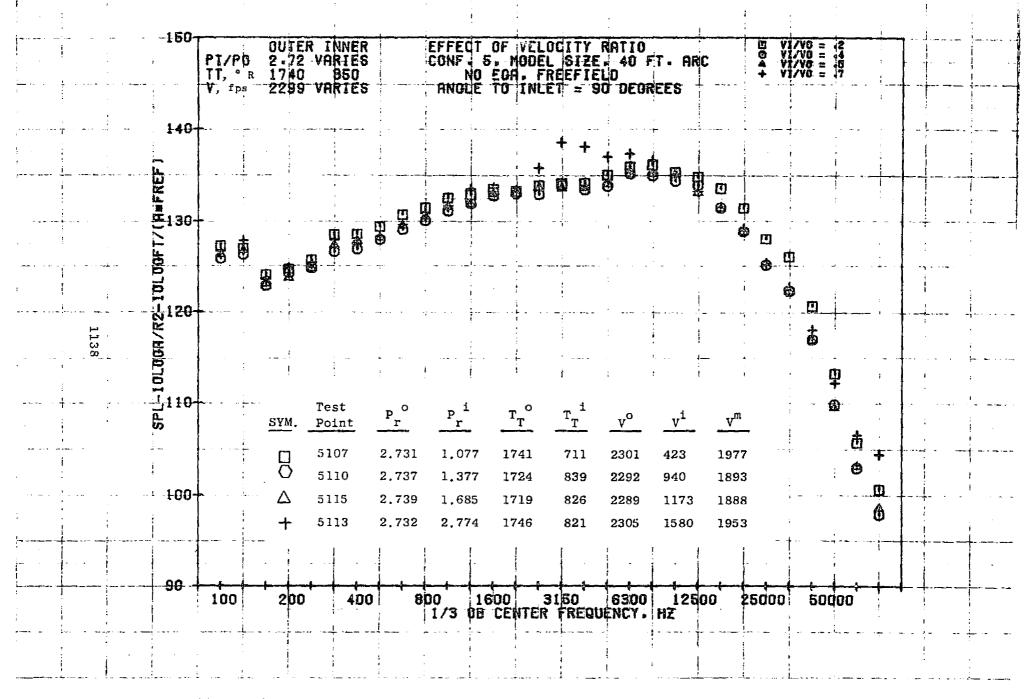
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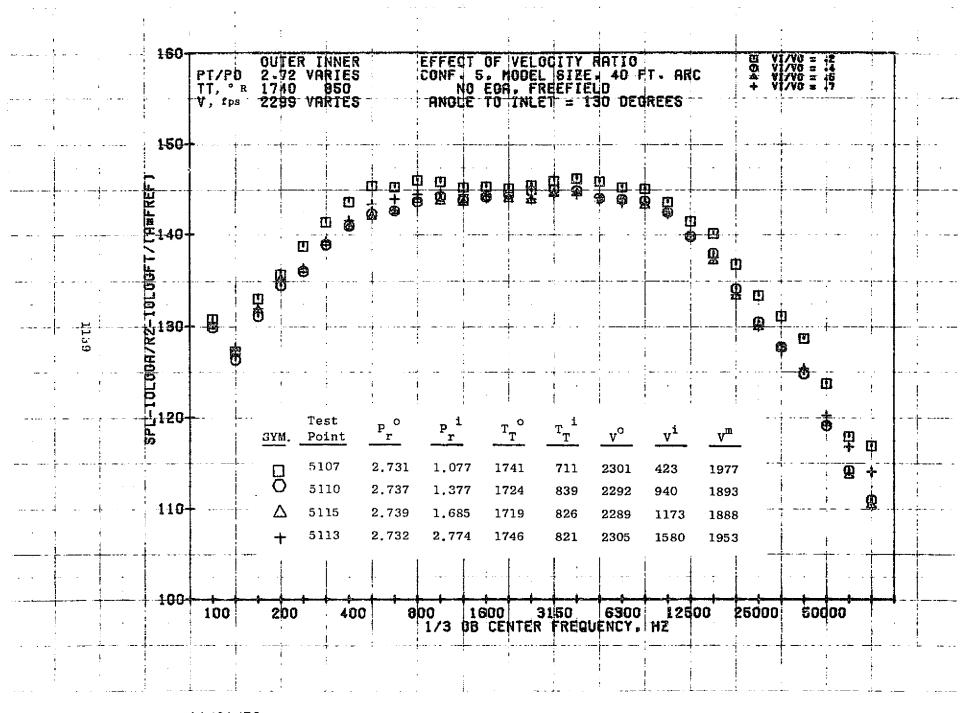
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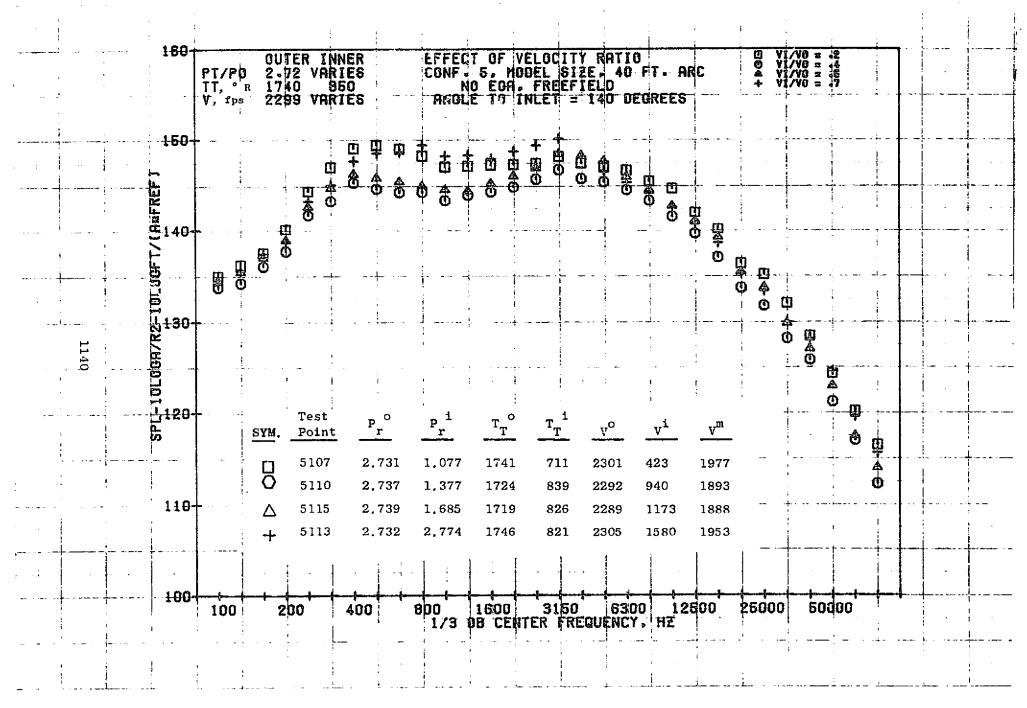


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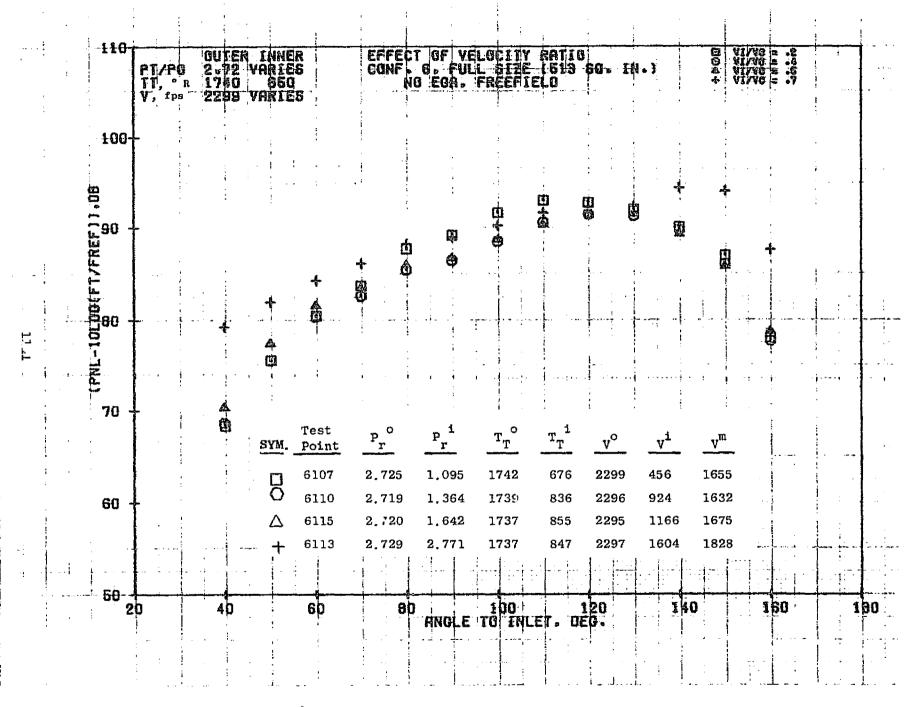






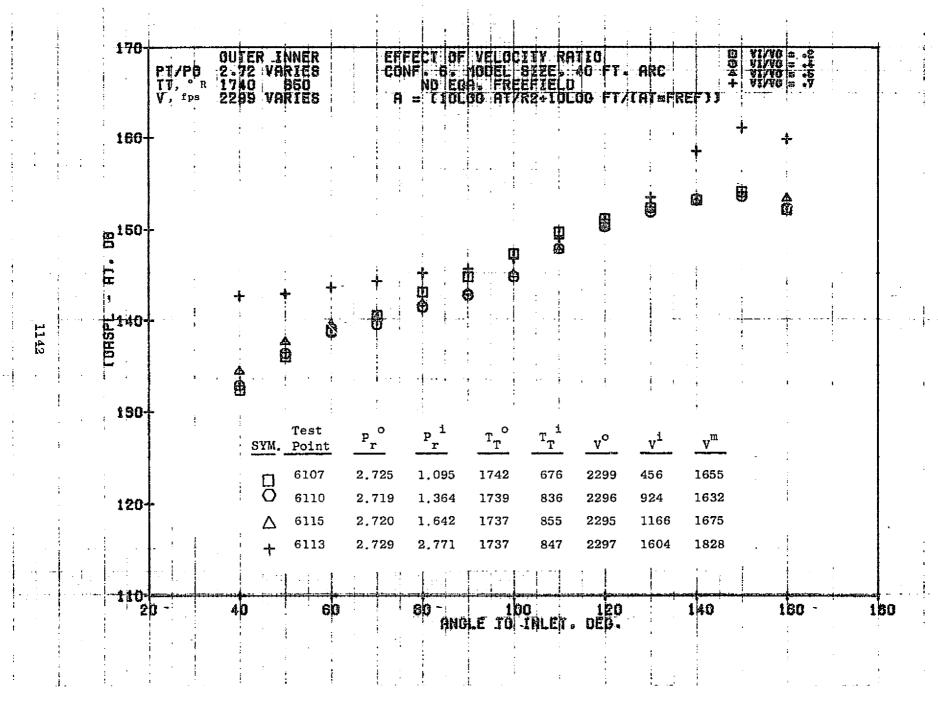


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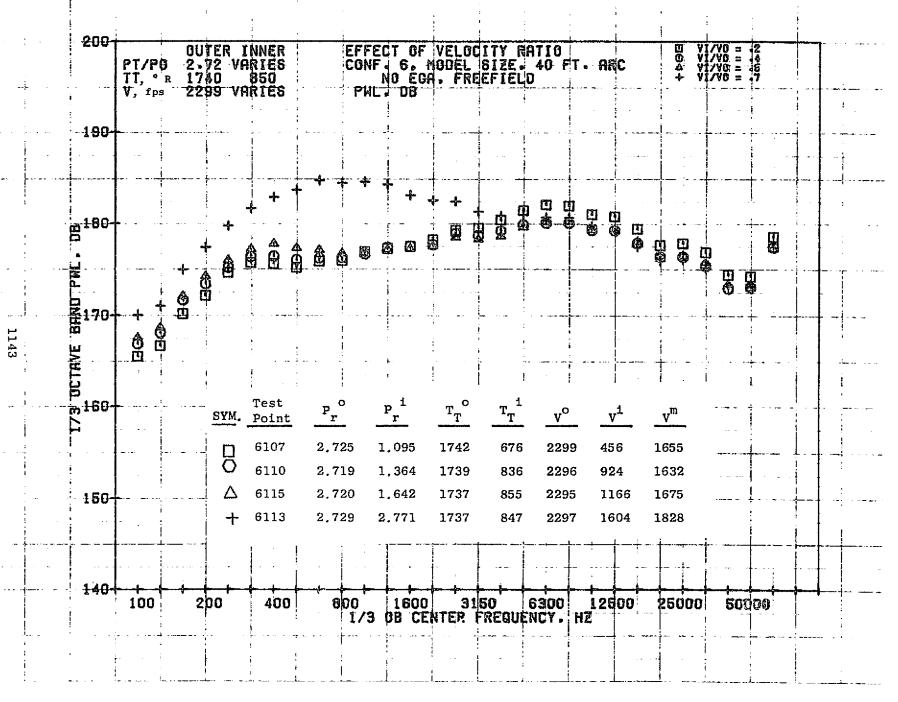
11/01/76 18421-001

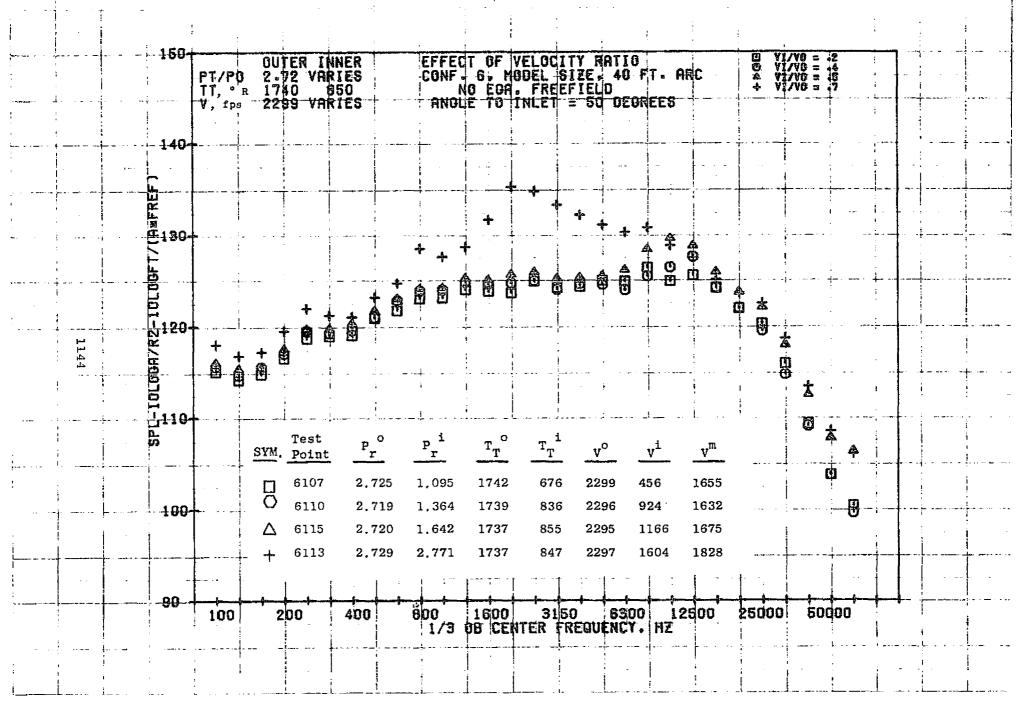
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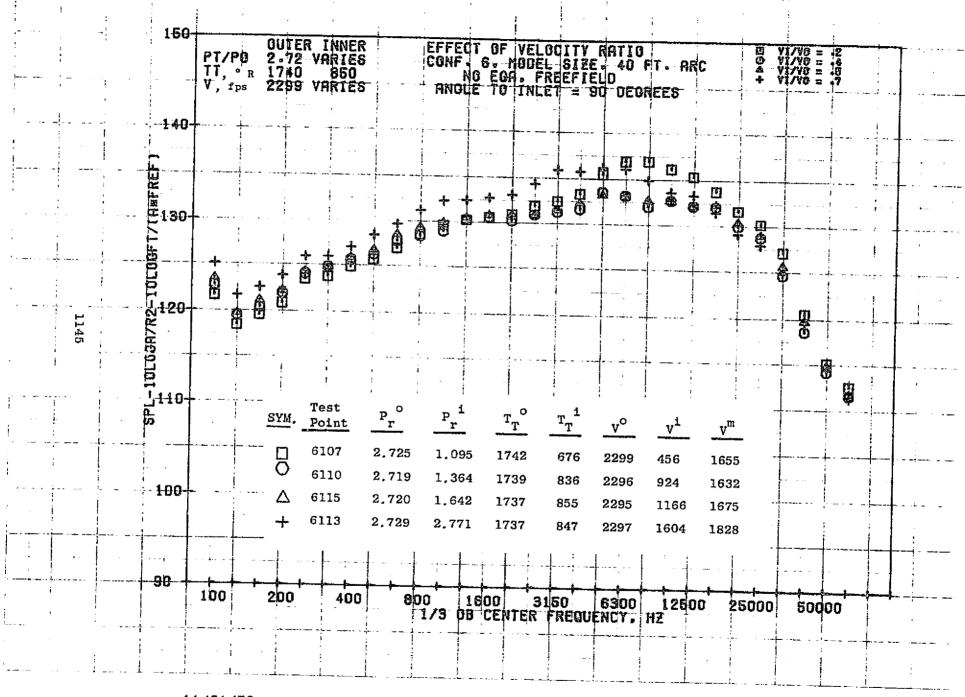


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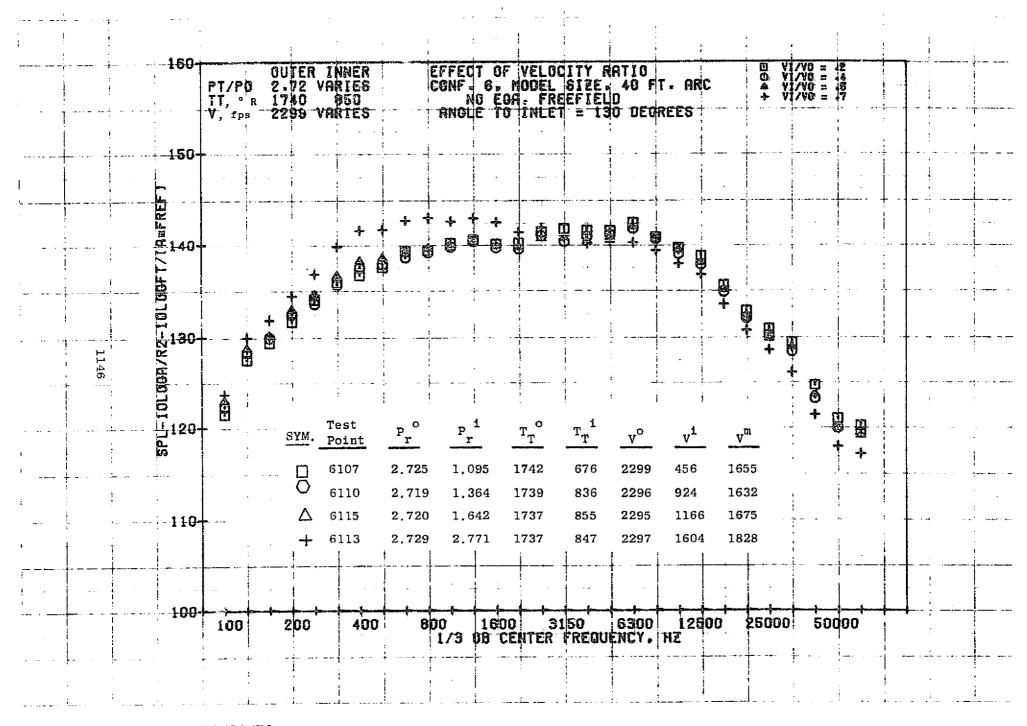
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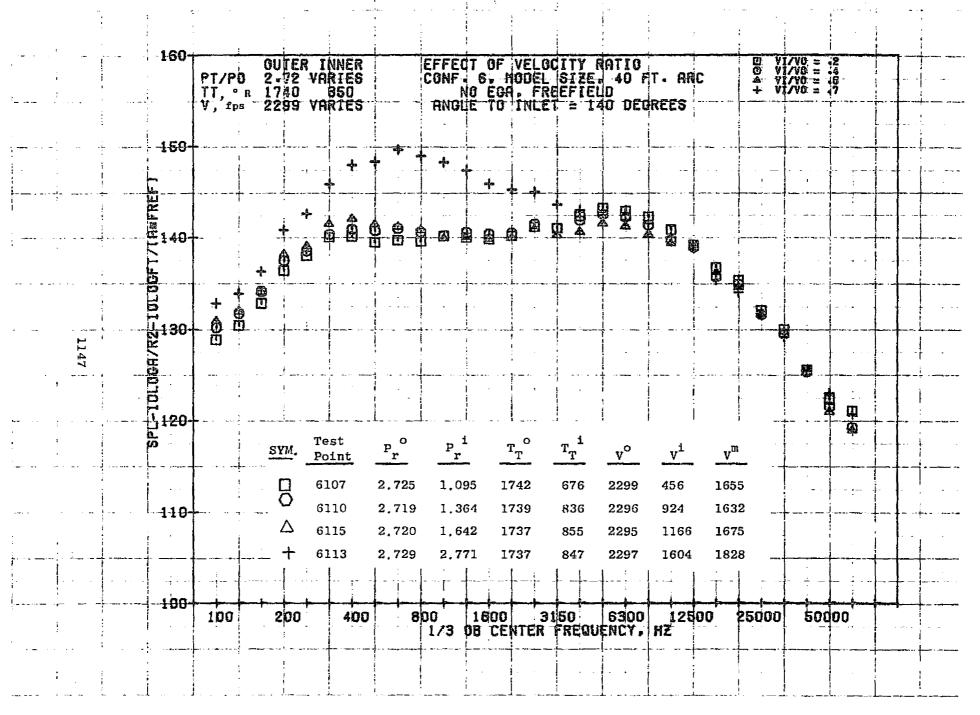


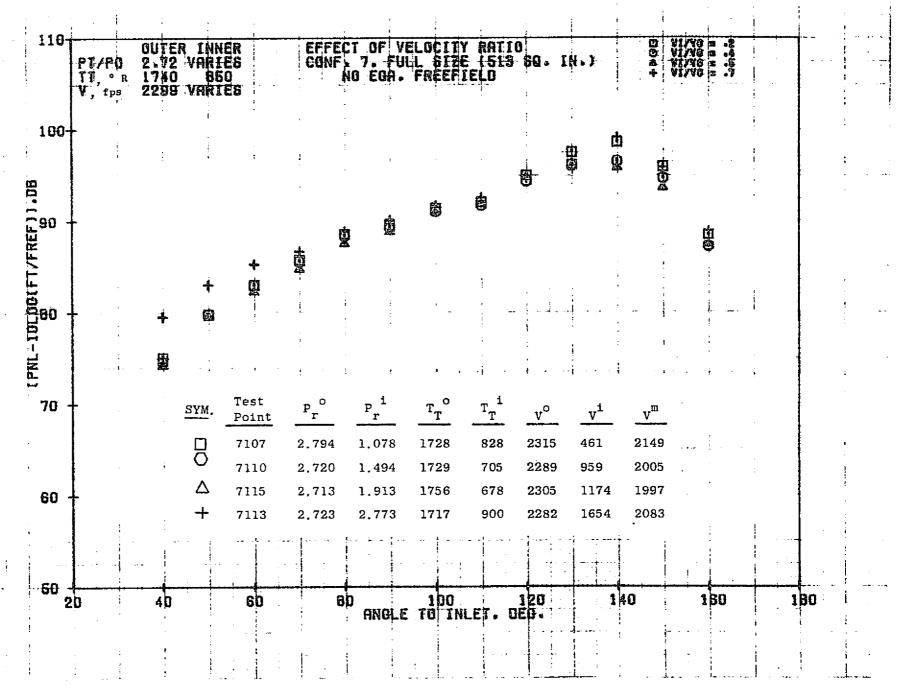




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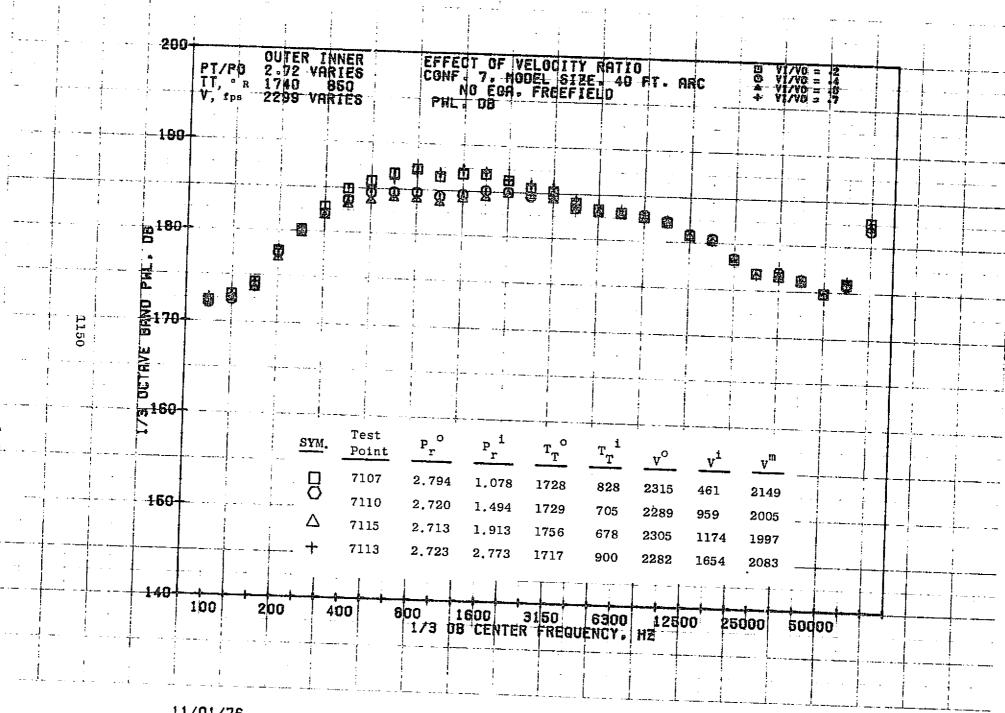


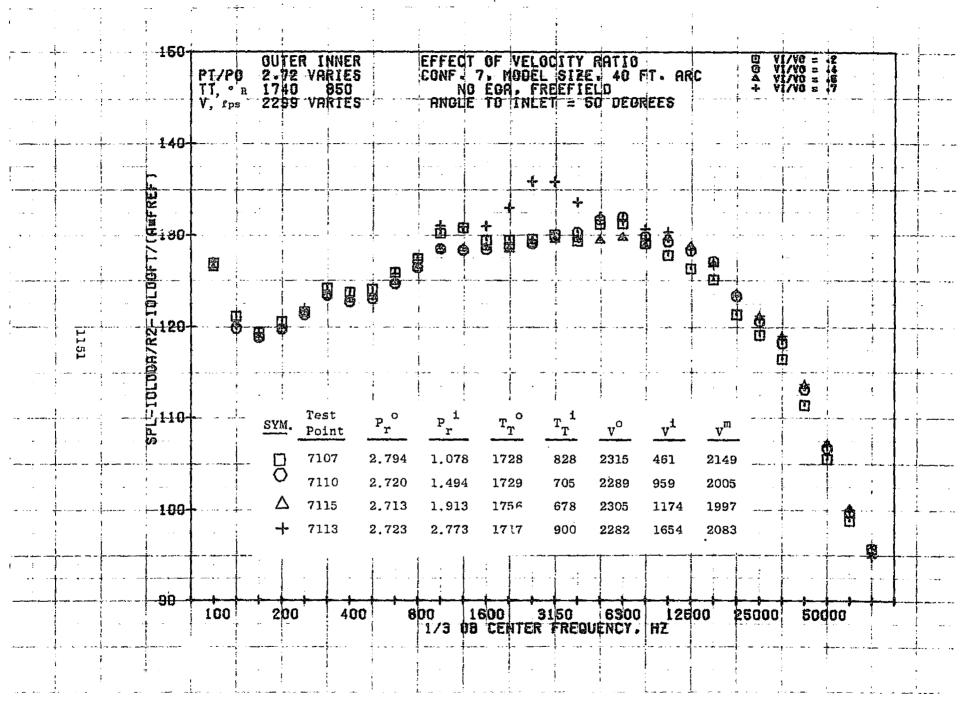
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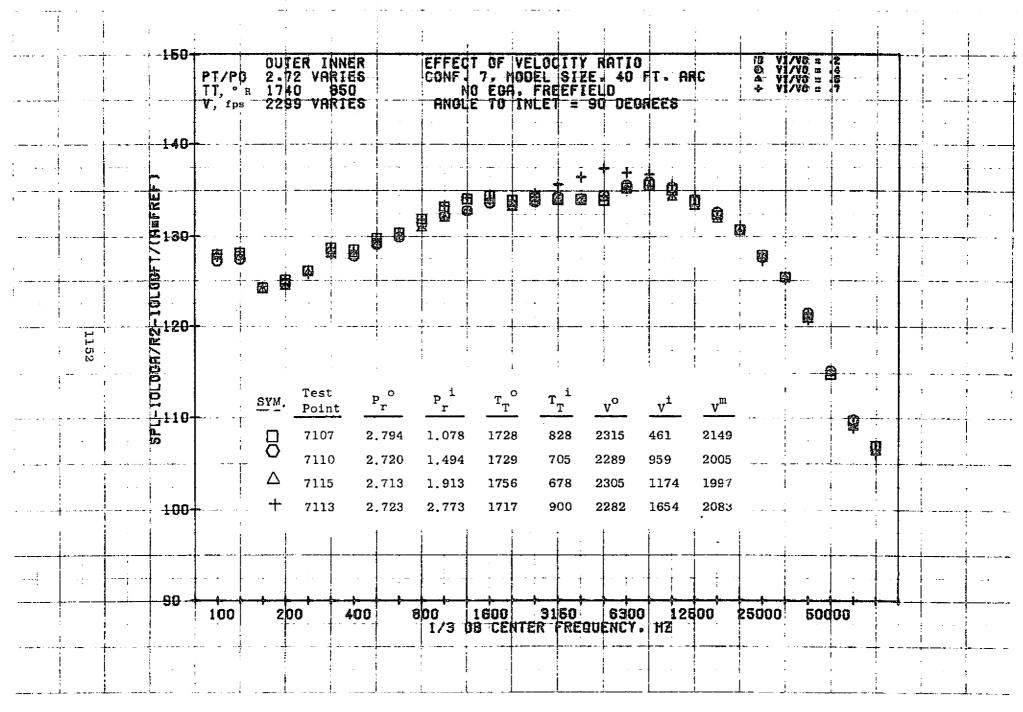
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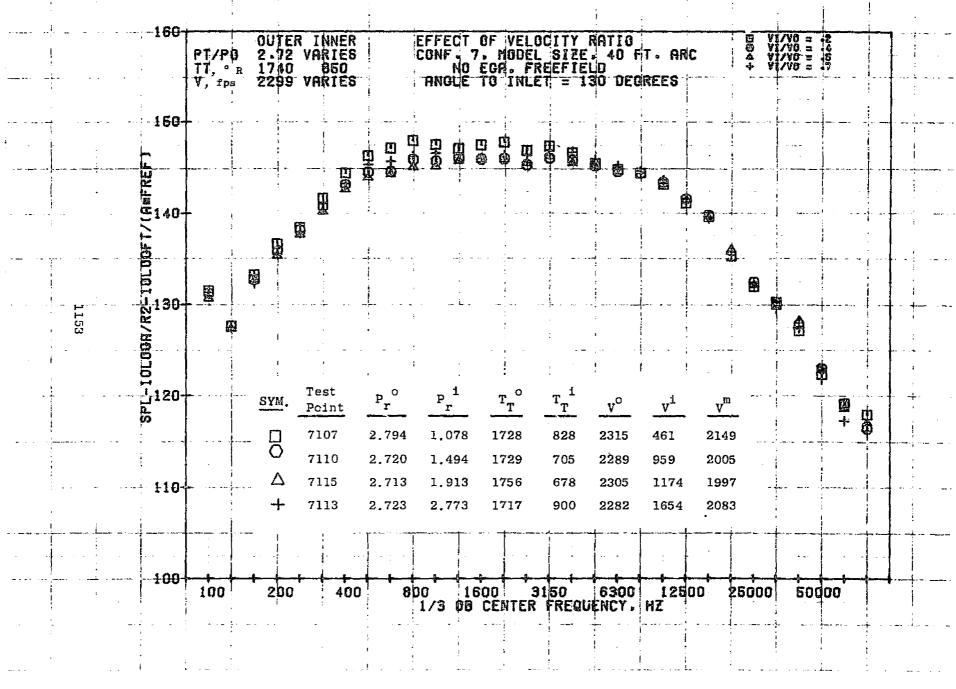
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79 RIIRCH A.



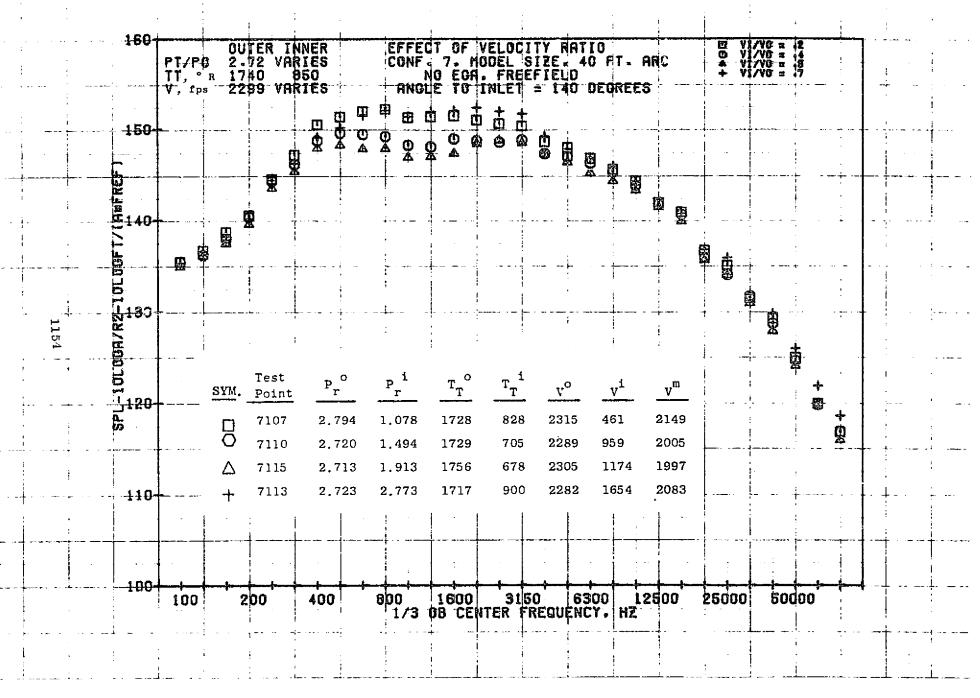






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79 BURCH A.



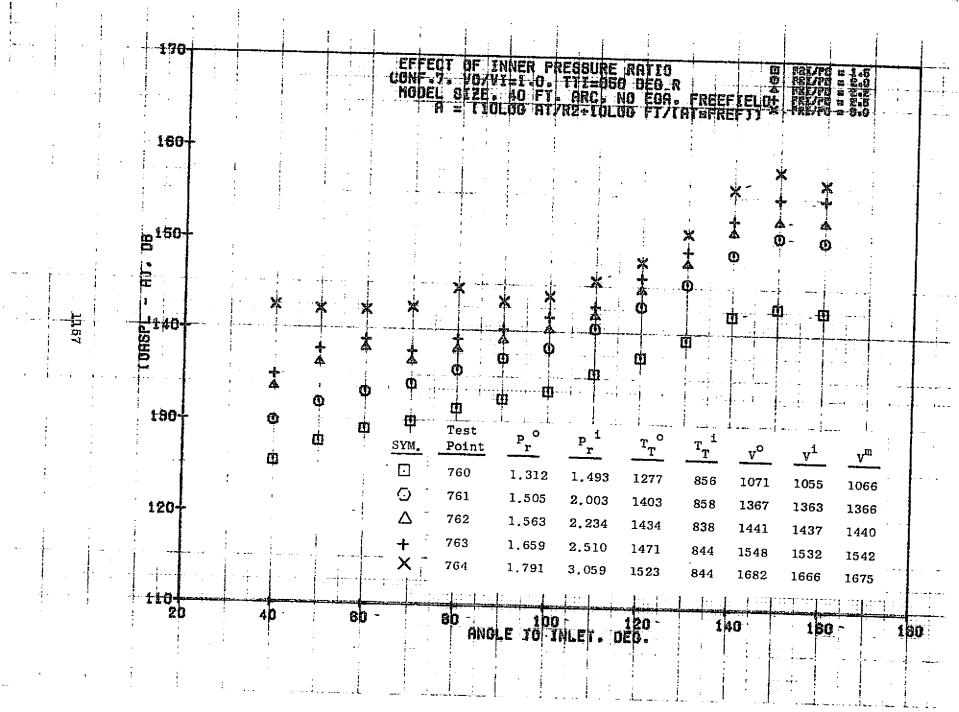
7.4.5 Effect of Inner Pressure Ratio at Constant Velocity Ratio

For Configuration 7, a test series was run in which the velocity ratio was held constant at different levels and the inner pressure ratio was varied. The results are shown in this section.

160	EFFECT OF CONF. VO/VI:	TINNER PRESSUR 7. FULL SIZE I 1.0. TTI#850 D	E RATIO 613 60. [N.] EO R	0 F61/F0 = 1.5 0 F61/F0 = 2.0 A F61/F0 = 2.2 A F61/F0 = 2.5 E F61/F0 = 2.5	
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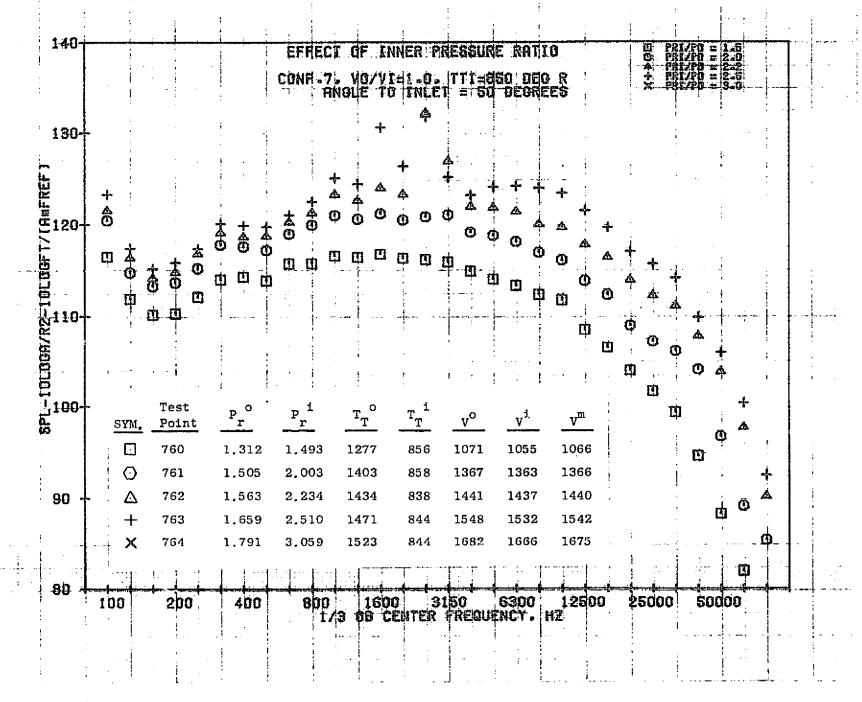
79 BURCH A.



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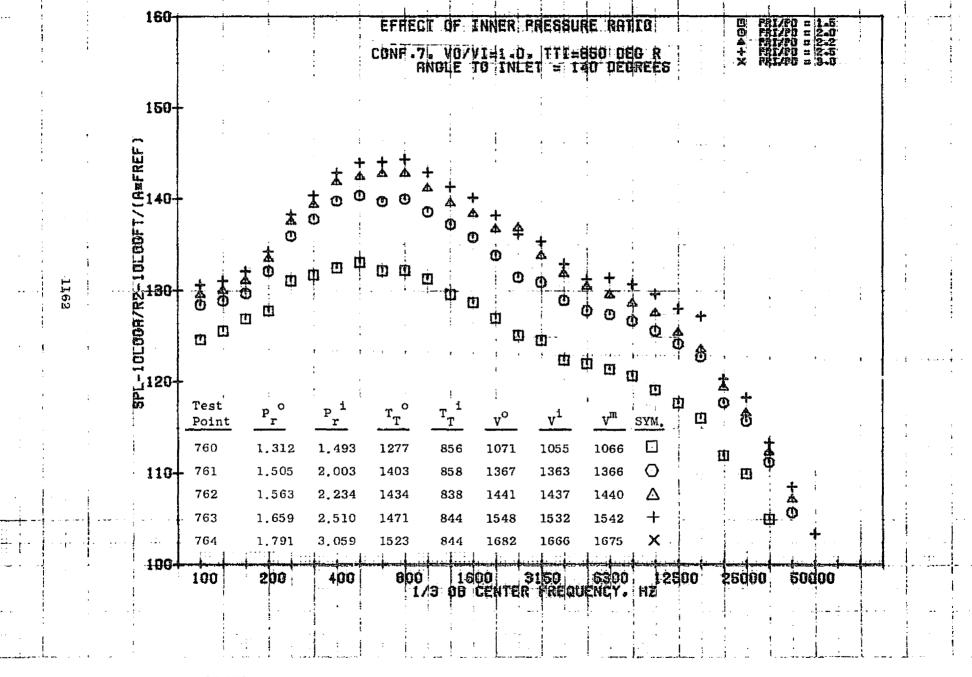
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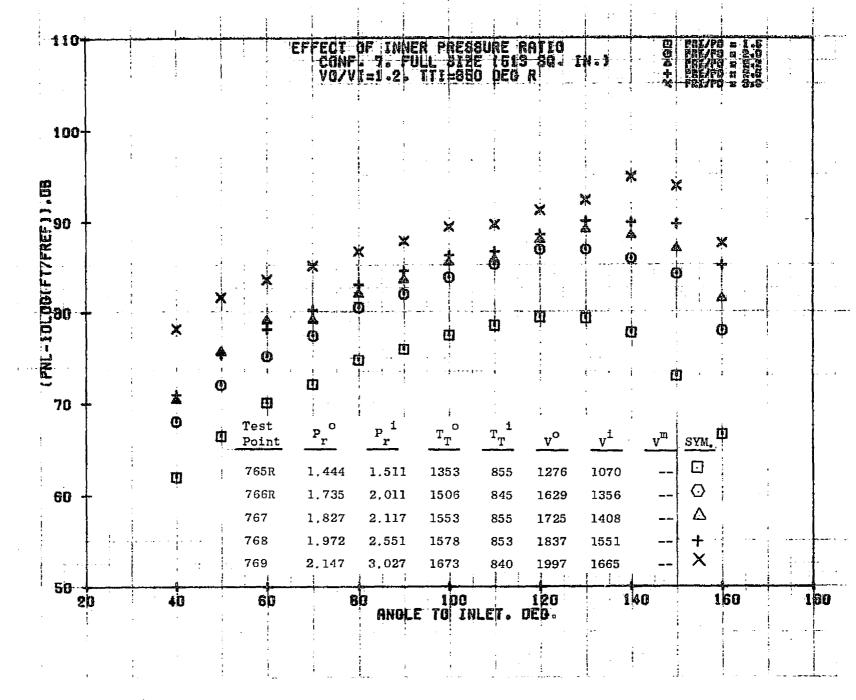
79 BURCH A.

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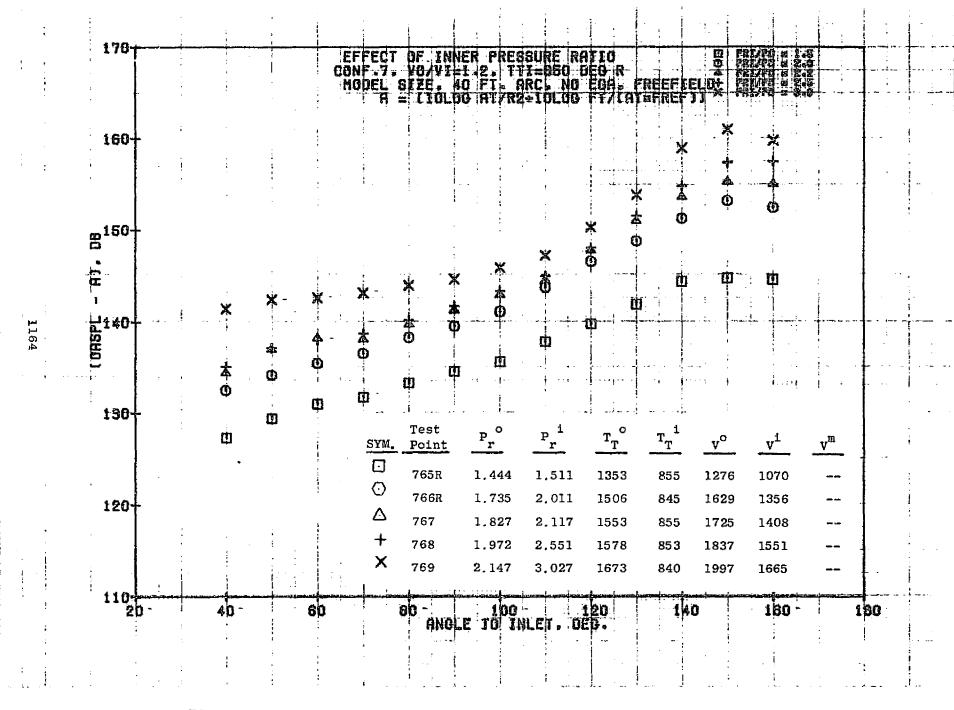


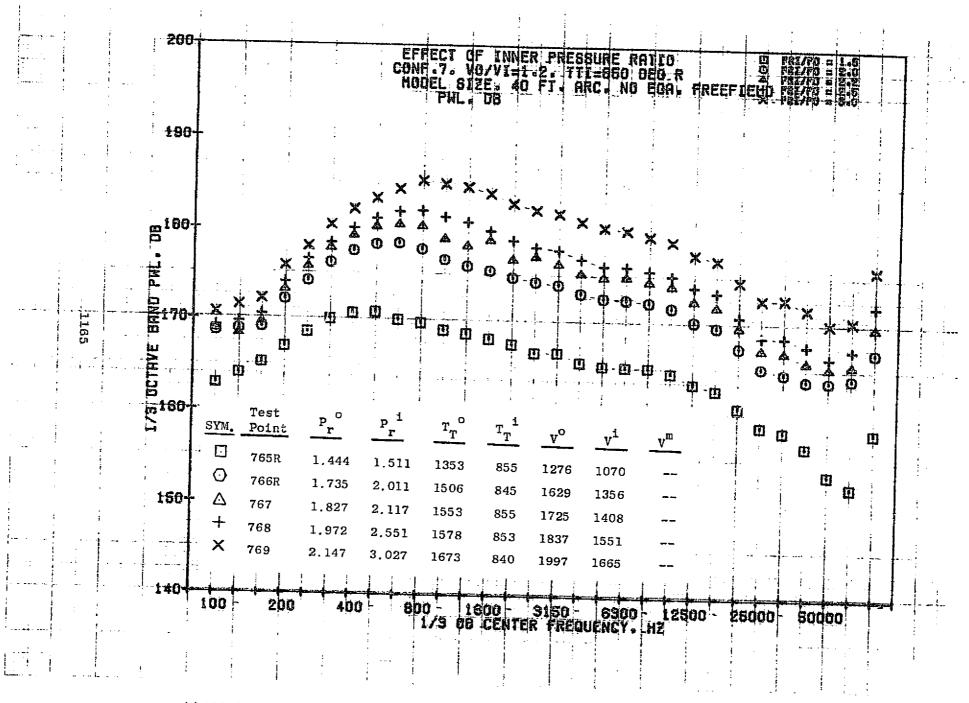


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79 BURCH A.



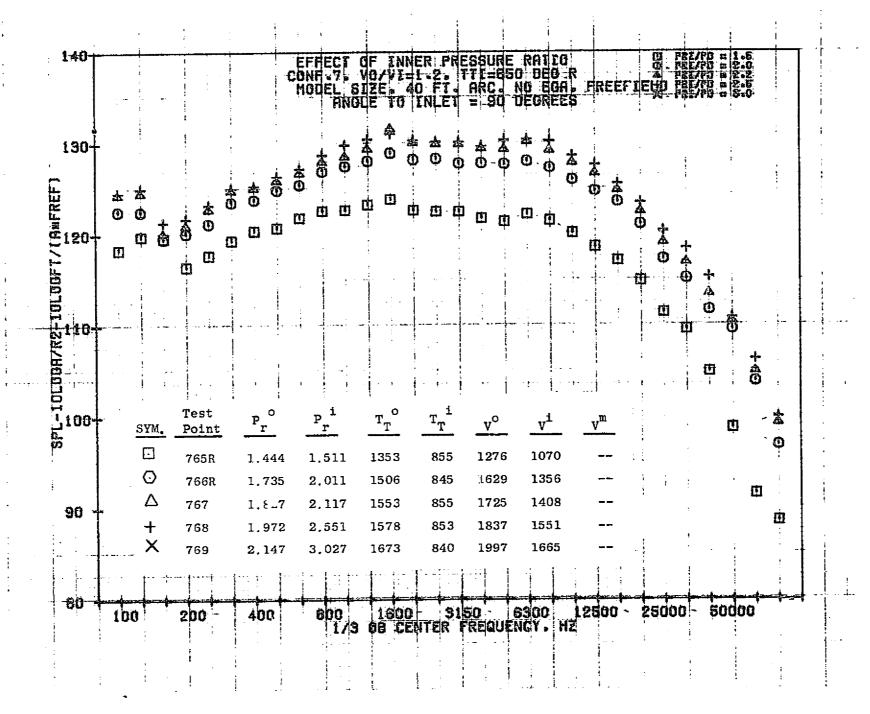


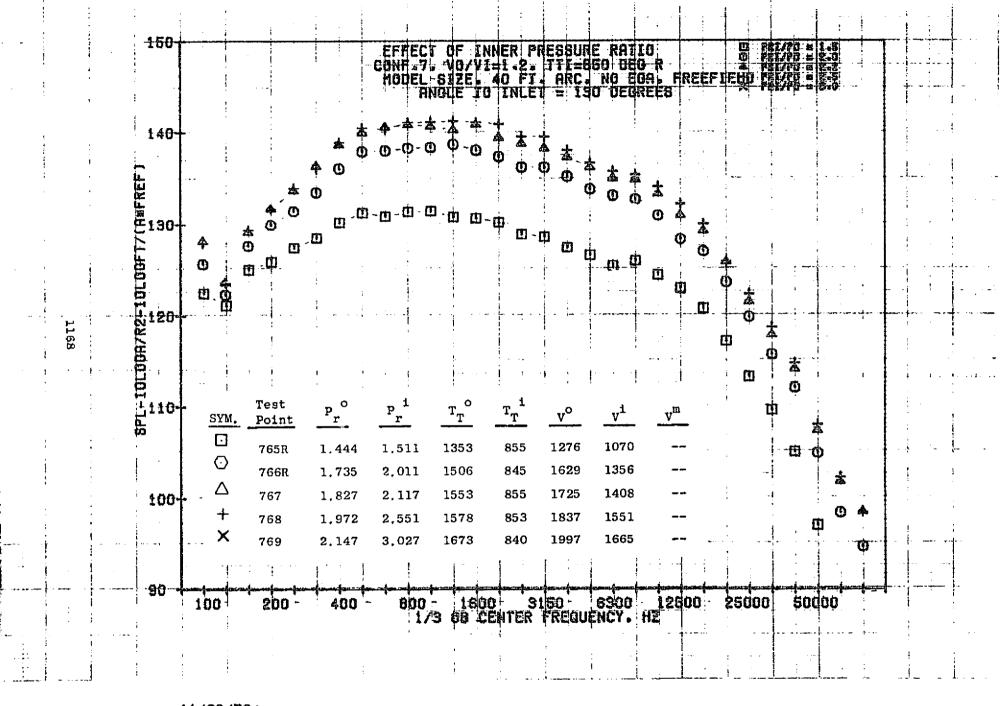
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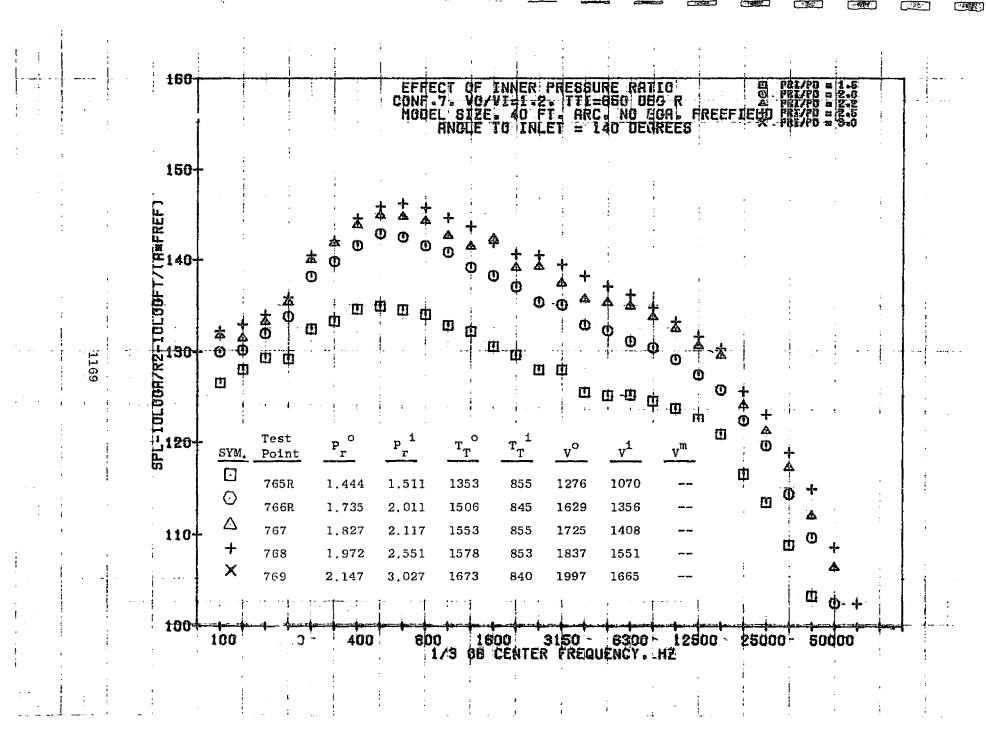
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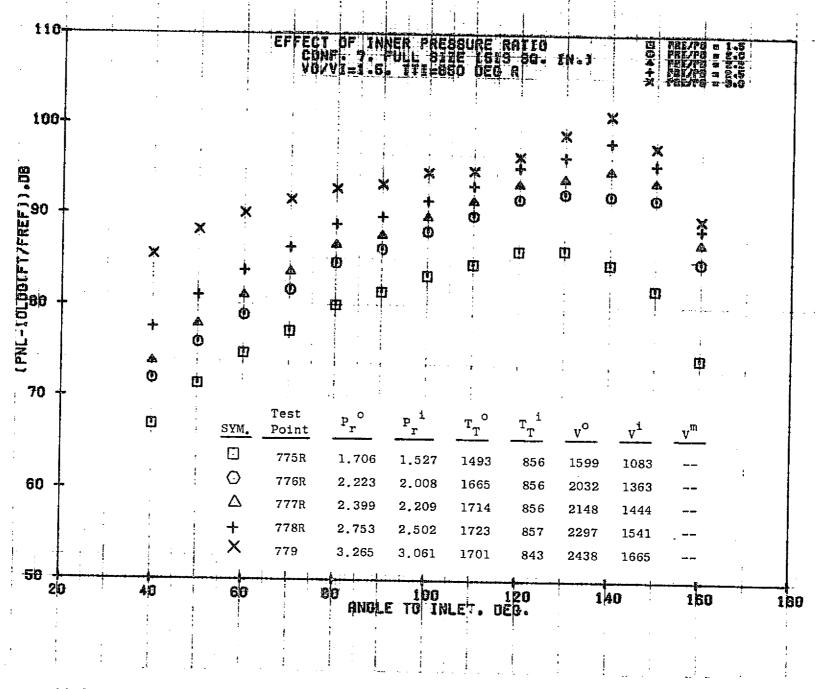
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79 RIBCH A.

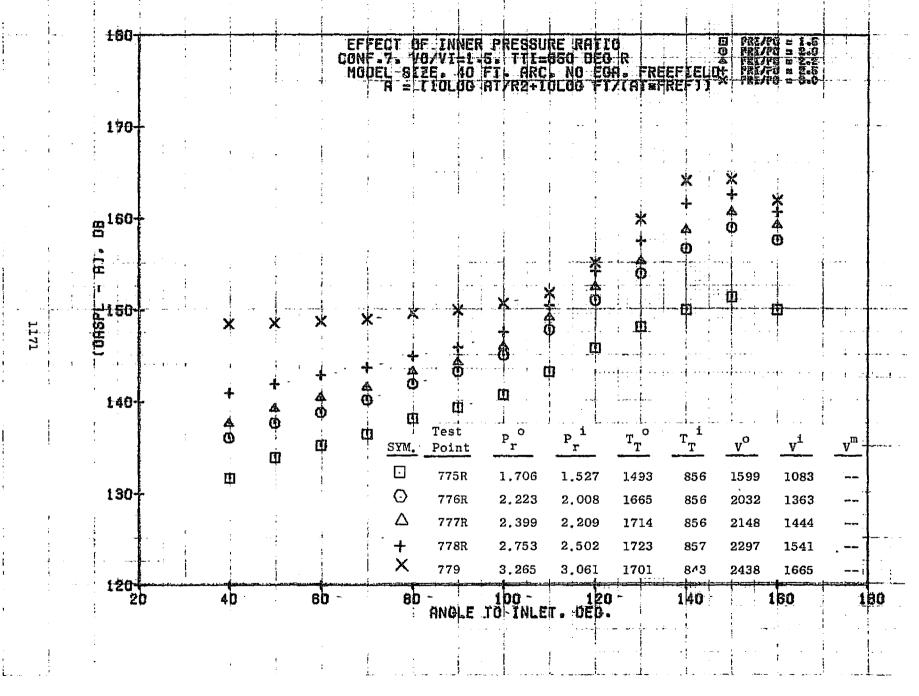




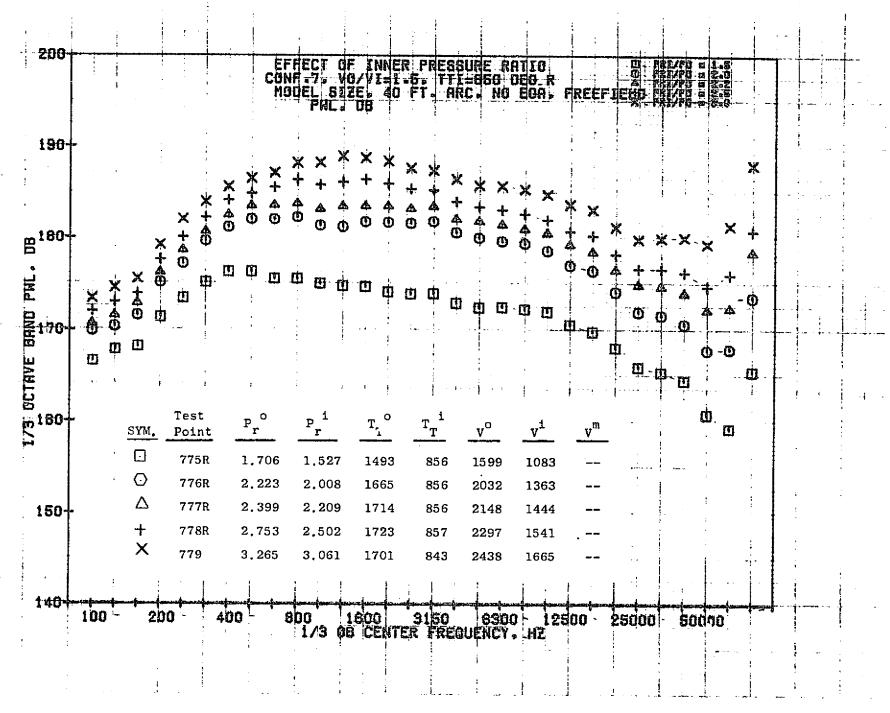


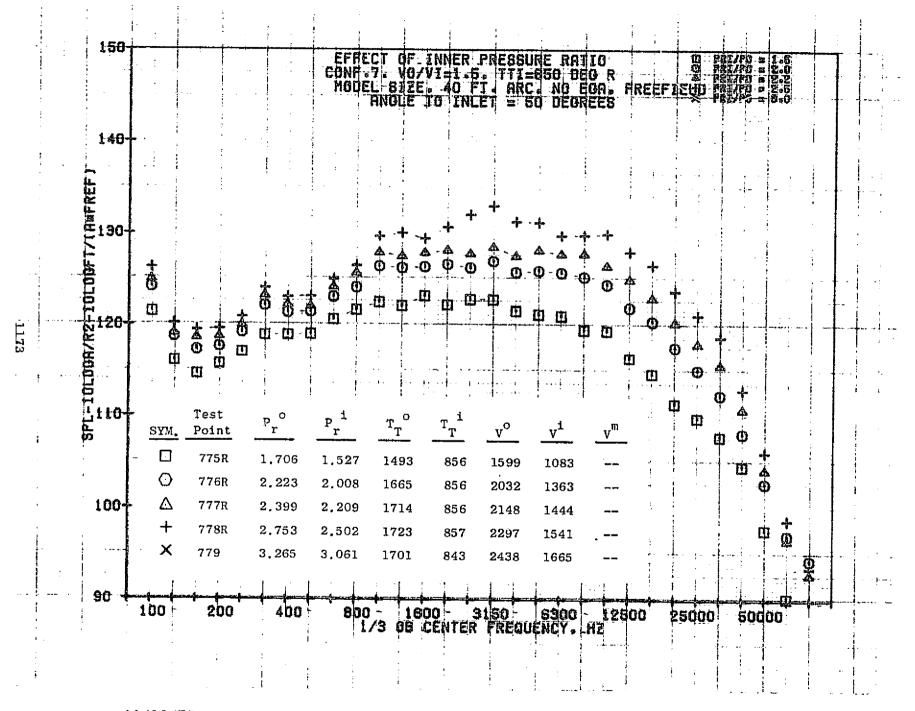


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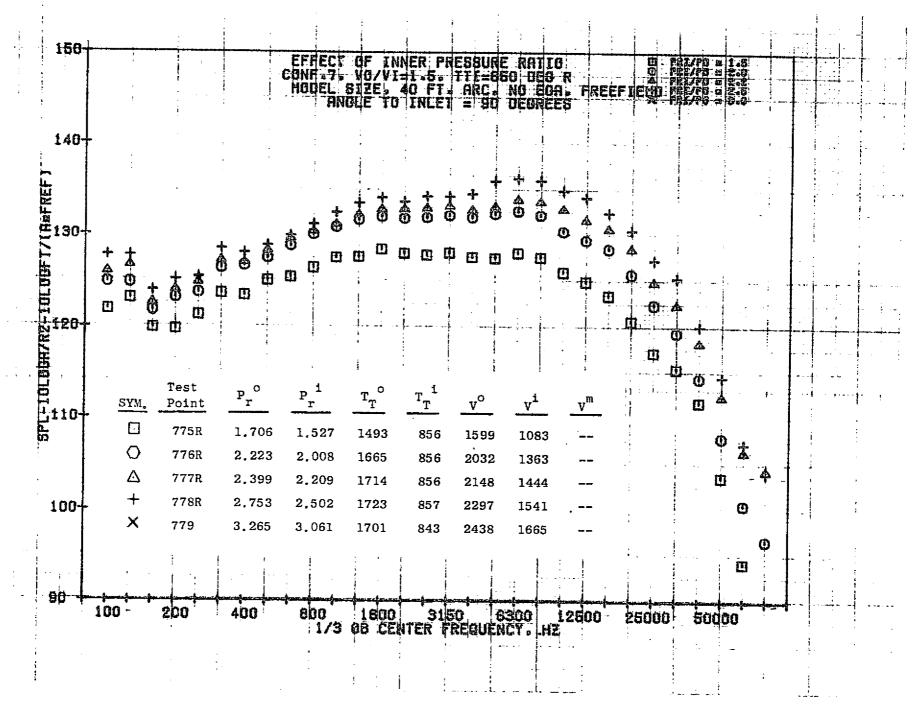


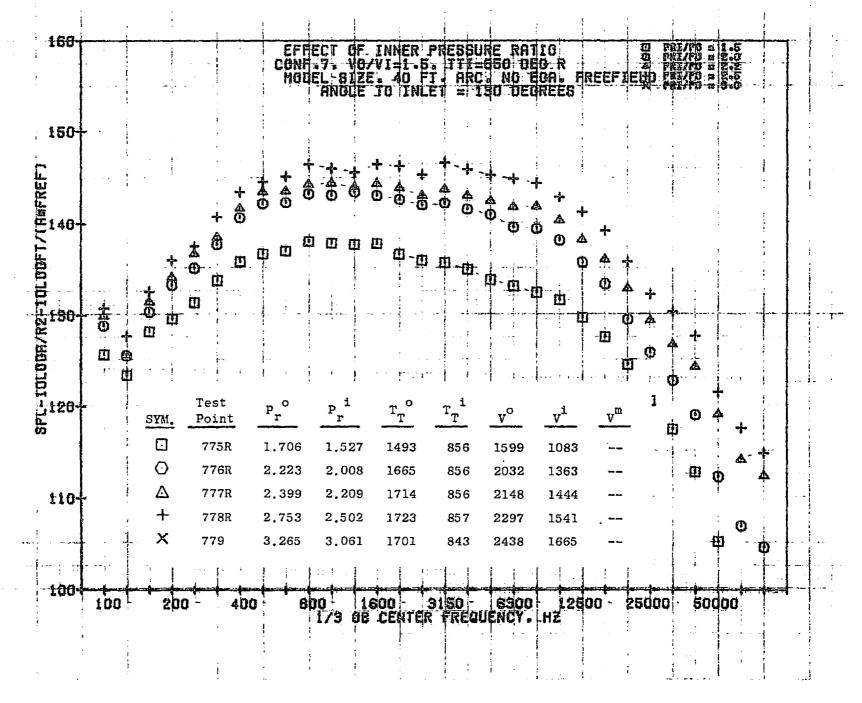
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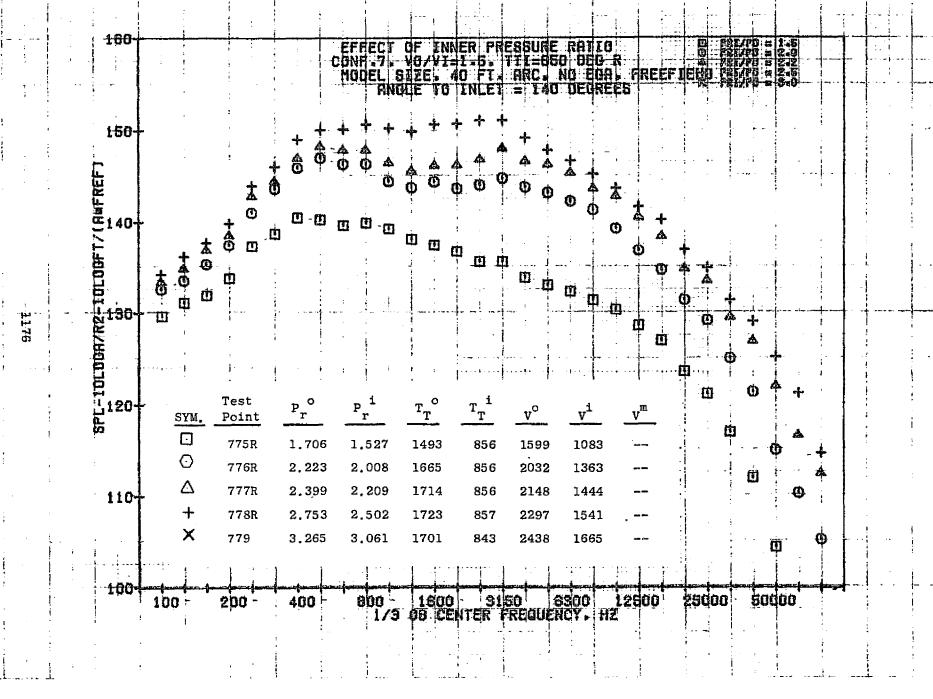
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79 BURCH A.

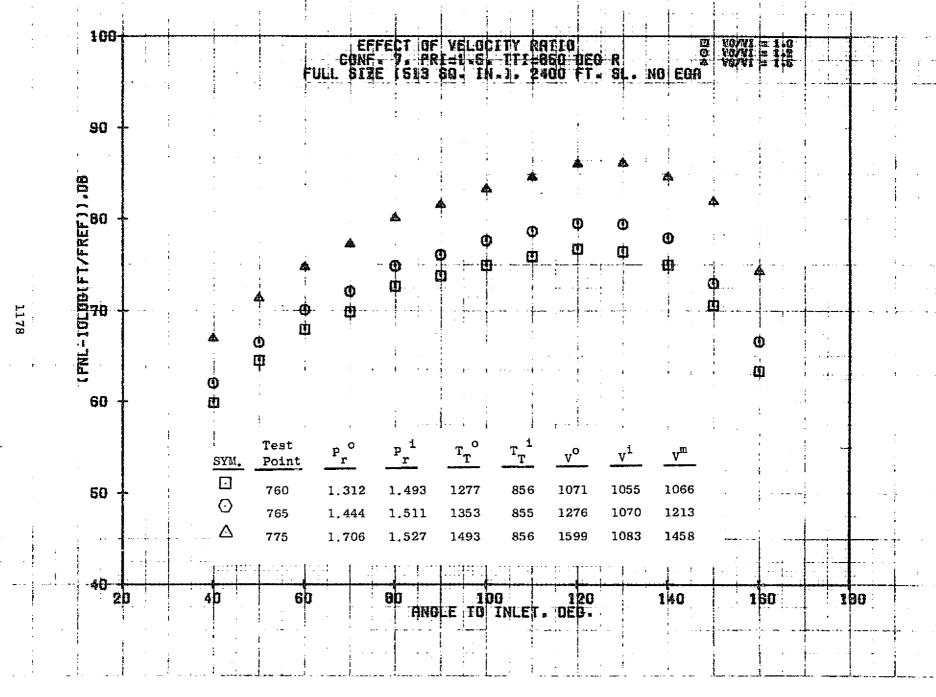
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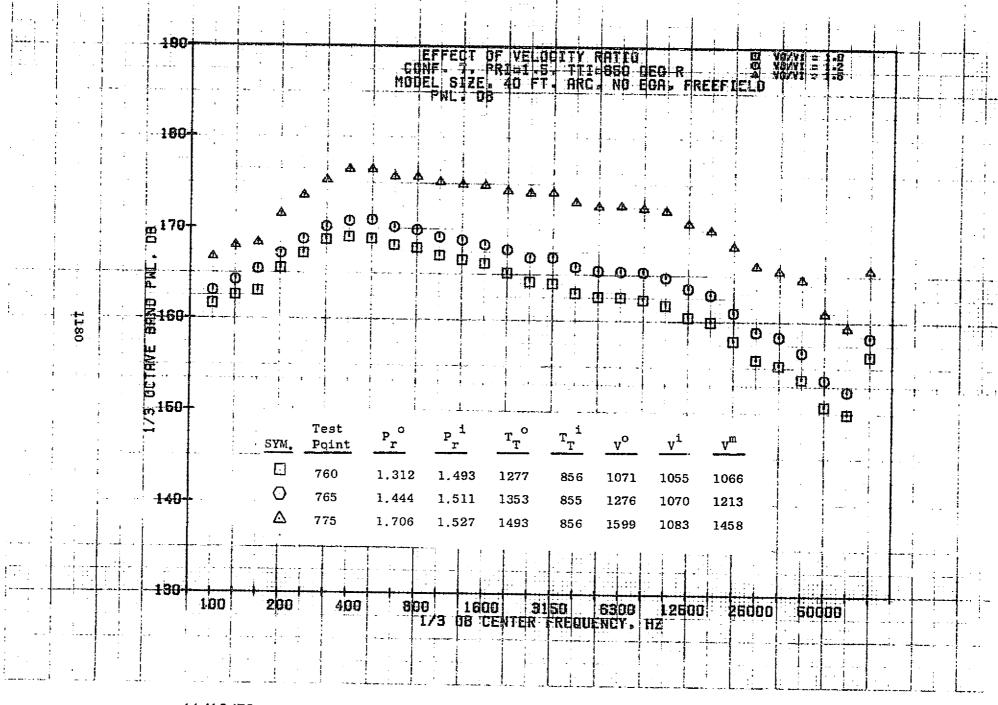
7.4.6 Effect of Velocity Ratio at Constant Inner Pressure Ratio

This section presents comparisons showing the influence of velocity ratio for a series of tests for Configuration 7 where the inner pressure ratio was held constant at different levels.

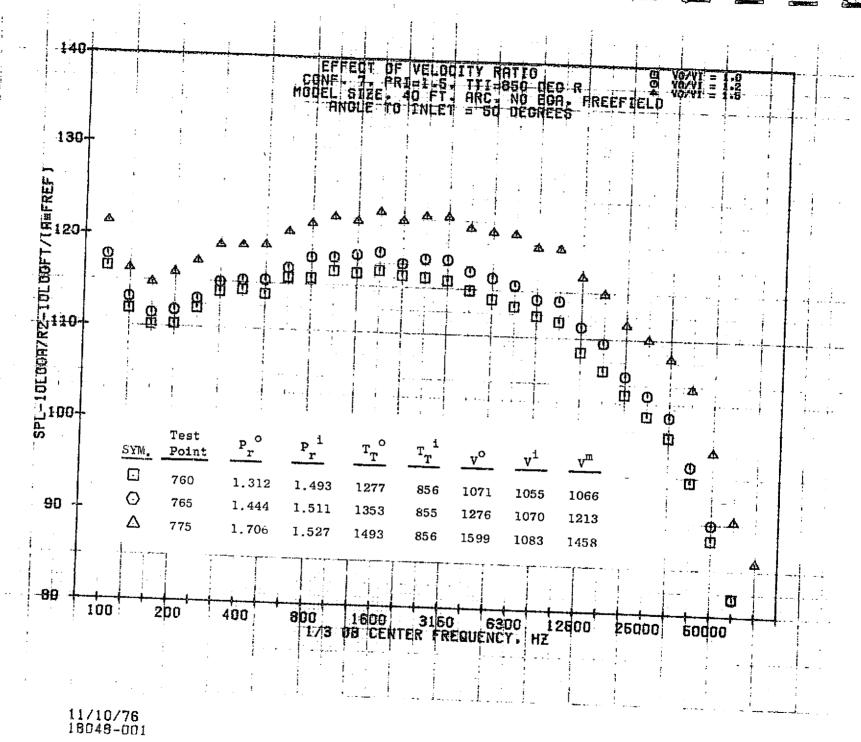


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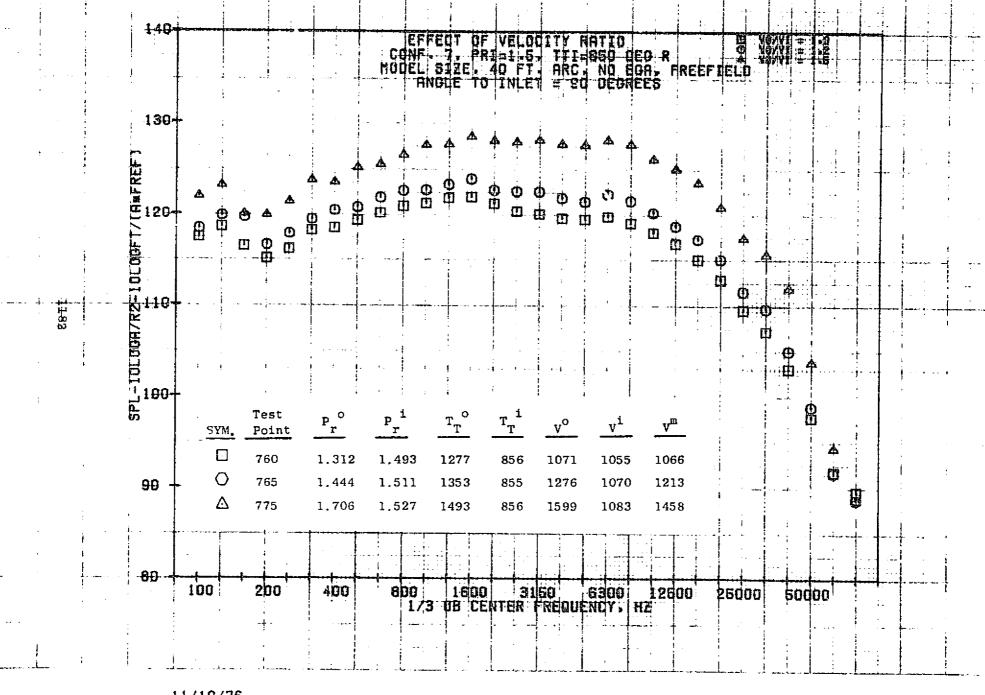
	150-			EFFECT CONF. 7. MODEL SIZE A = 11	OF VELOCITY PRI=1.5. IT . 40 FT. ARG OLOG ATYRZ+	RATIO 1=850 DEG R 1 NO EGA. F 1 DEGG FT/(A)	REEFIELD WFREFI)	Y0/VI = 1:0 Y0/VI = 1:2 Y0/VI = 1:8	
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				f	100 INGLE TO INLI	ET. DEG.			



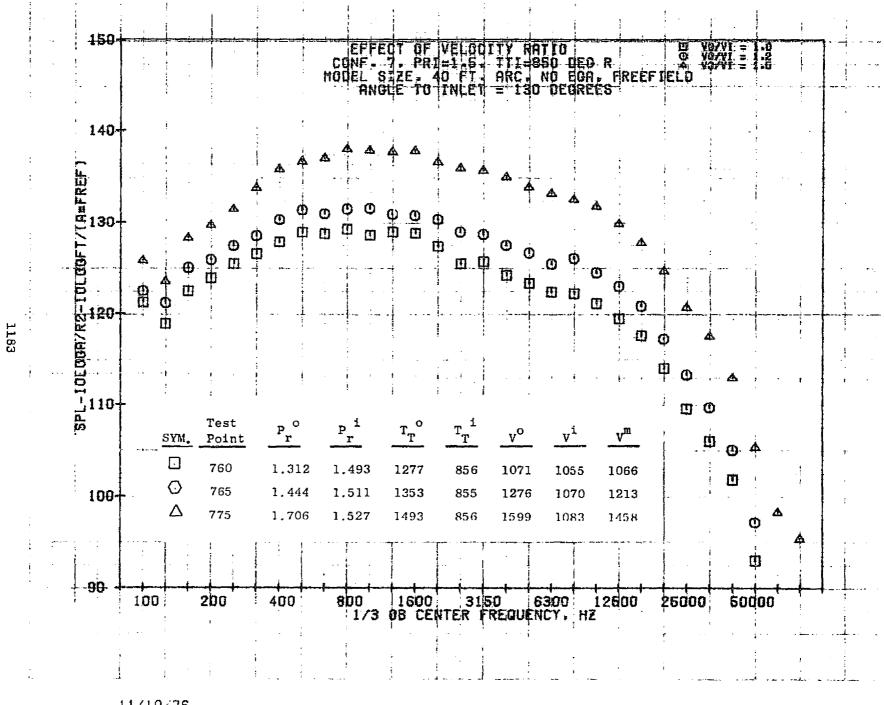
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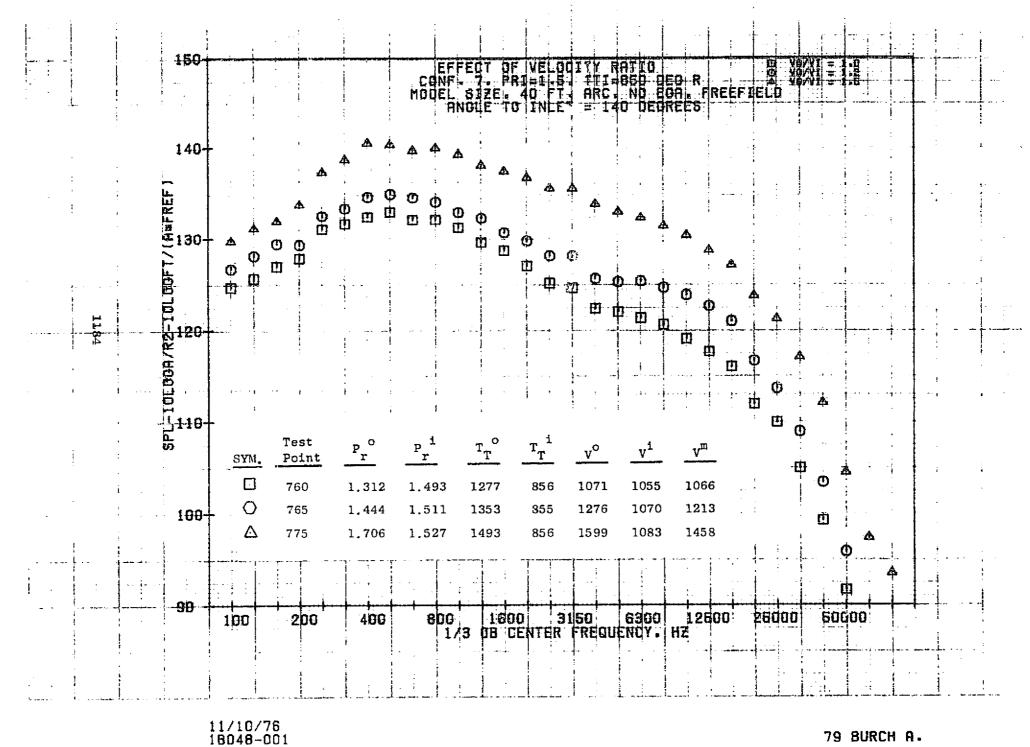
11/10/76 1B048-001

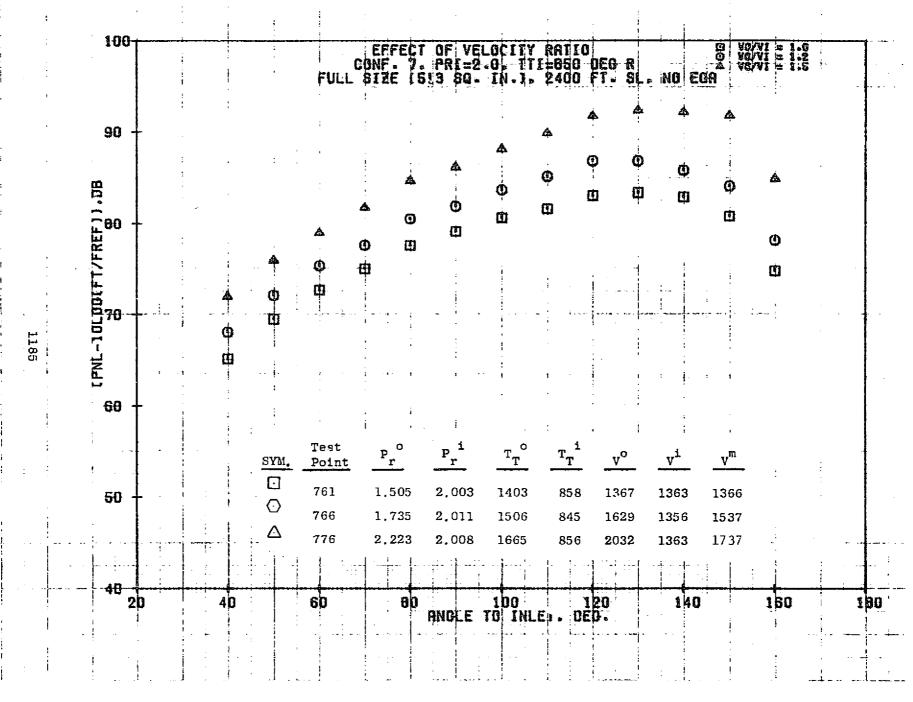


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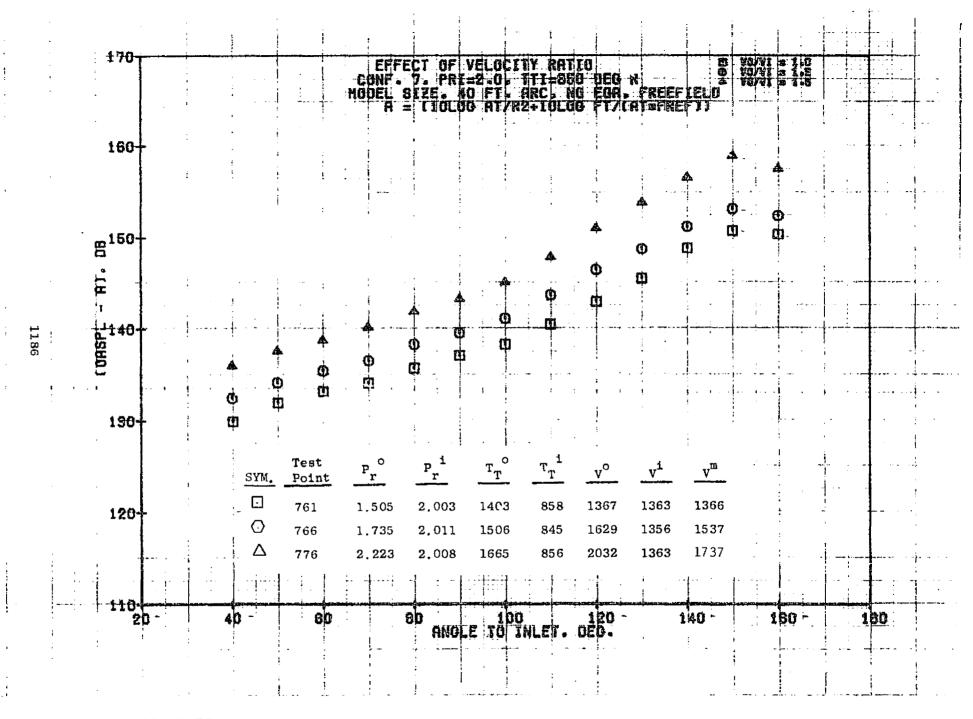
79 BURCH A.

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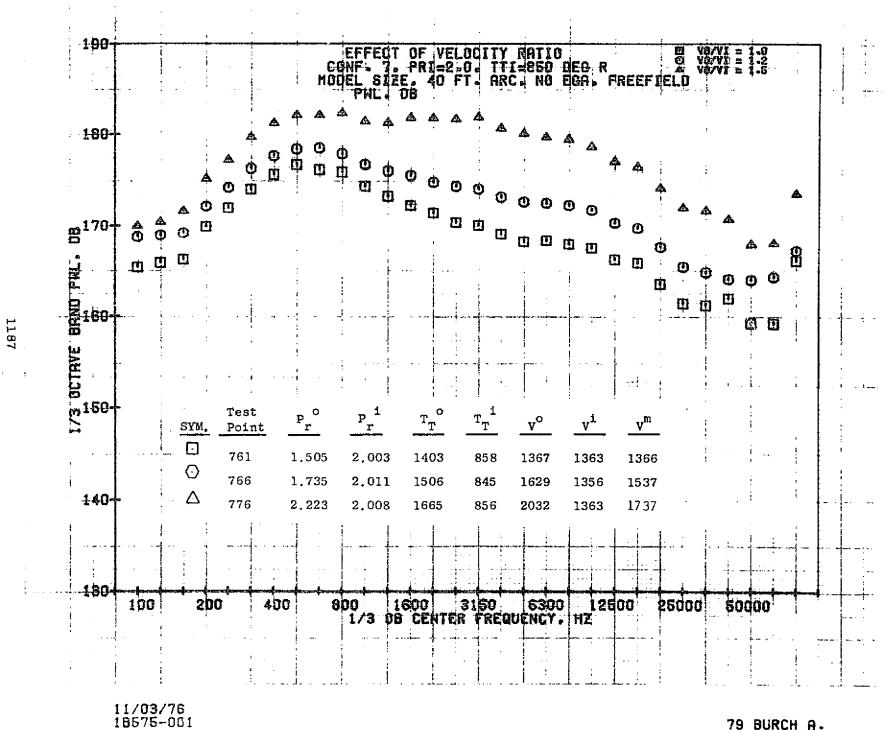


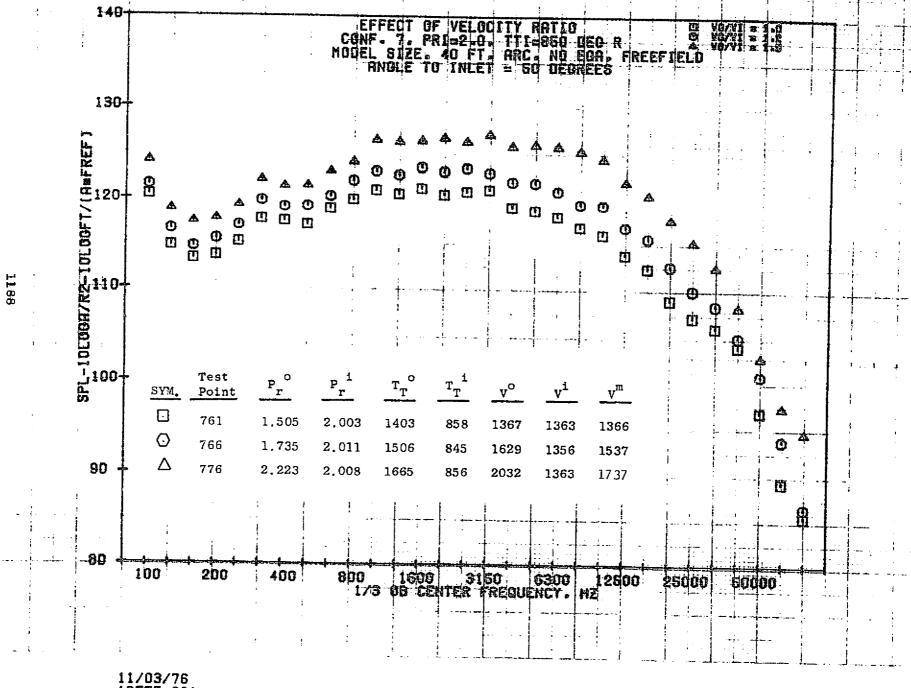


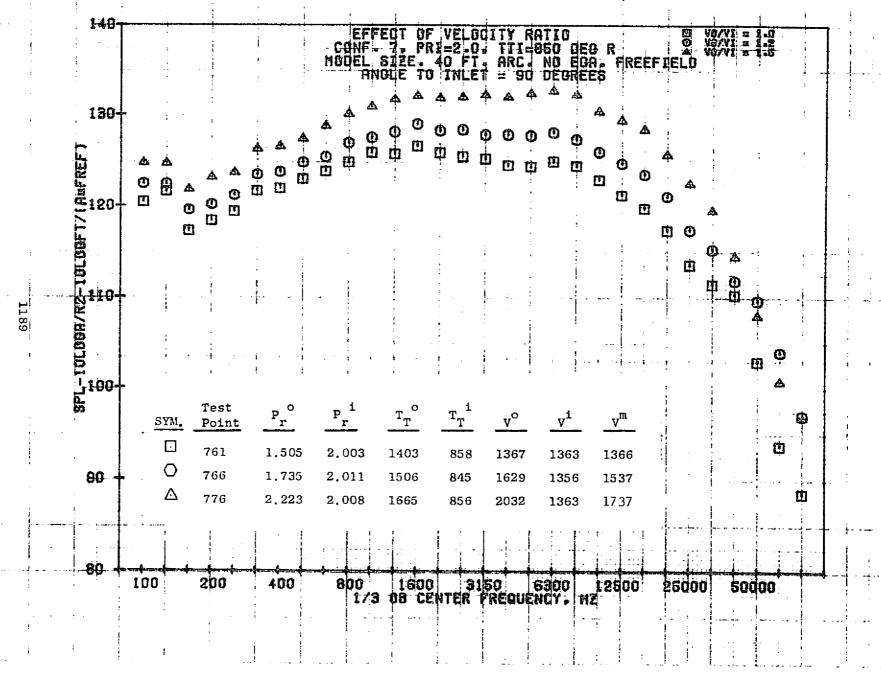
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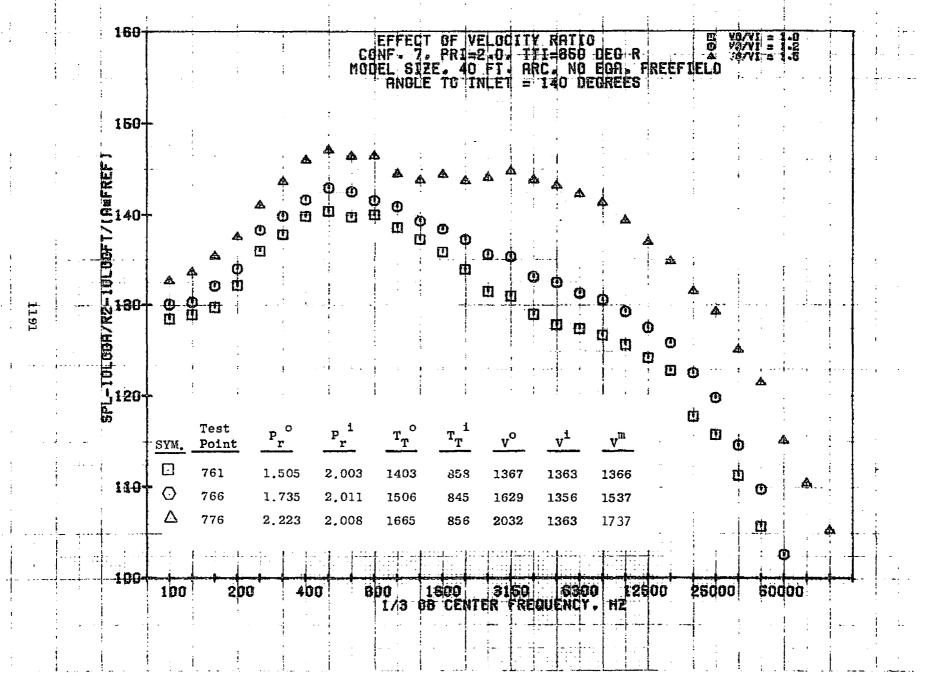


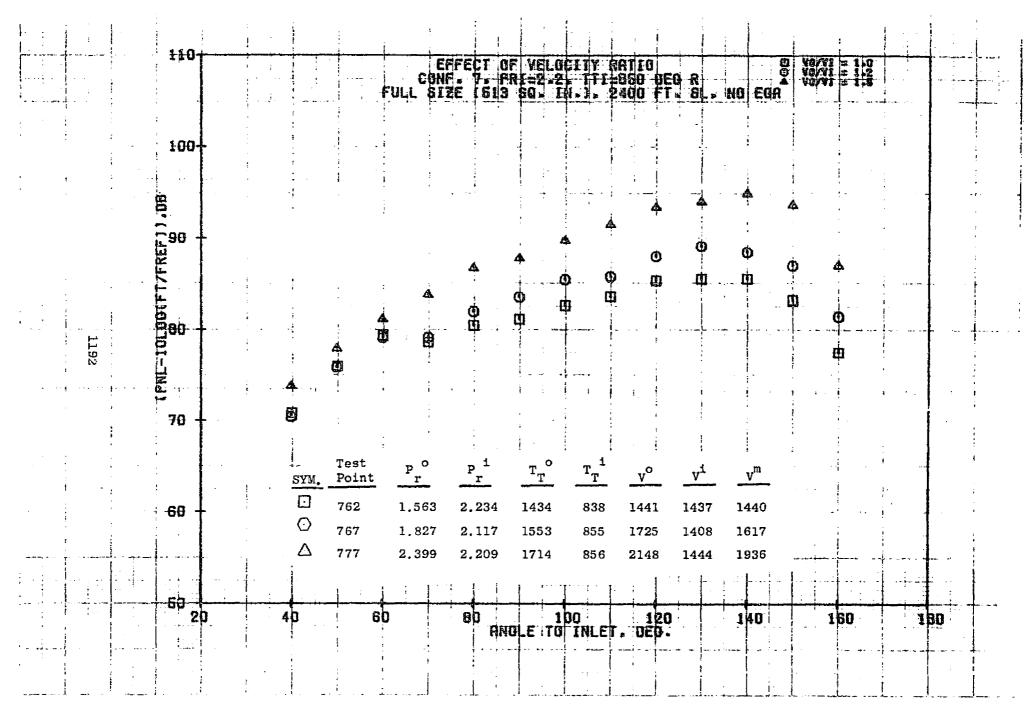


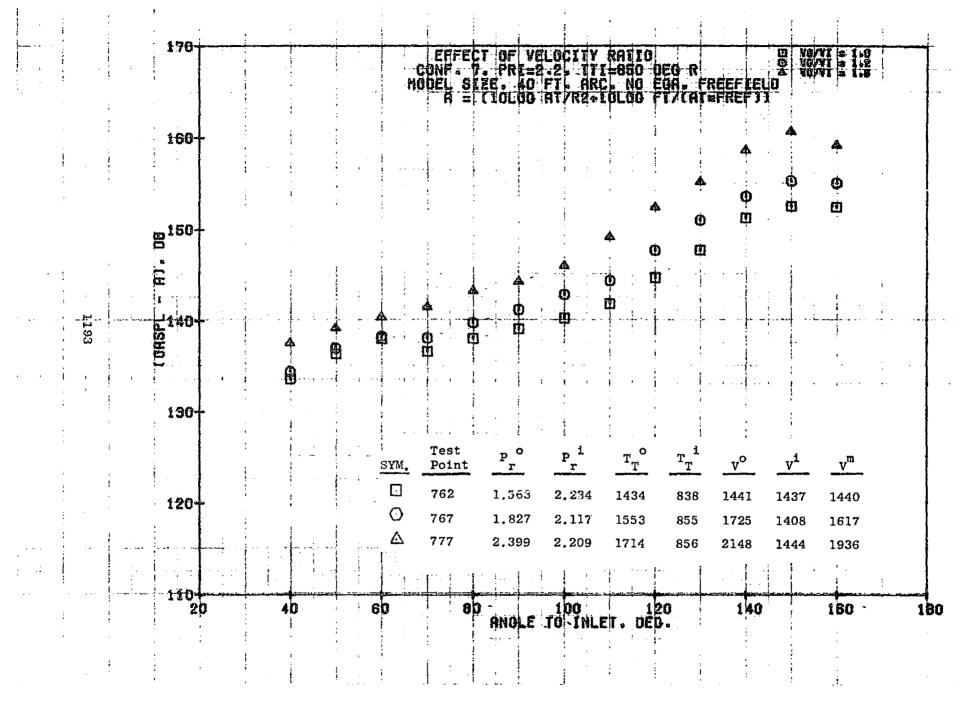


79 BURCH A.

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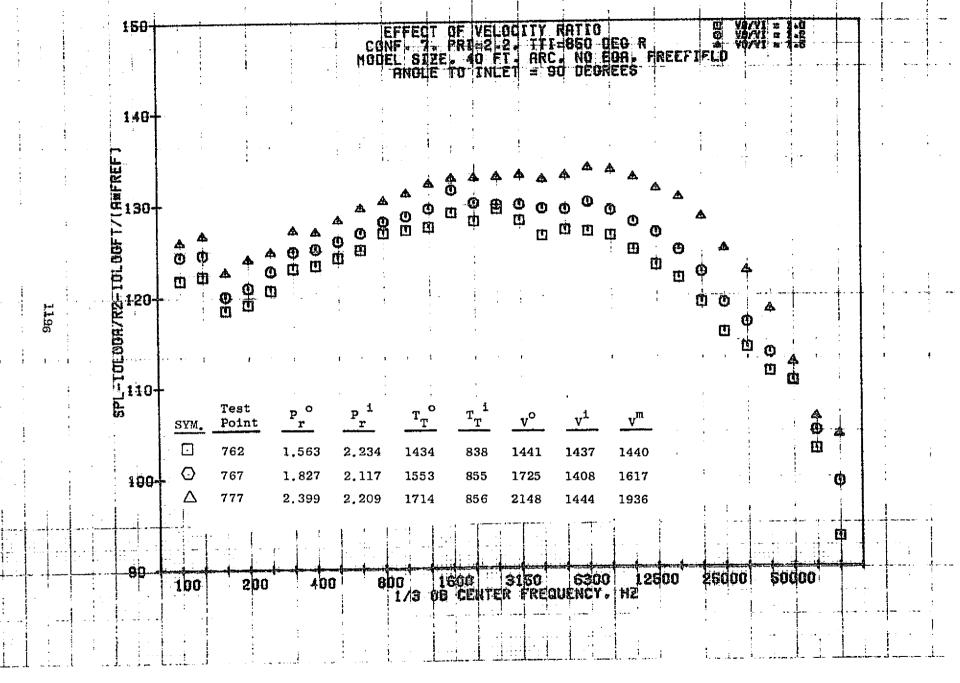
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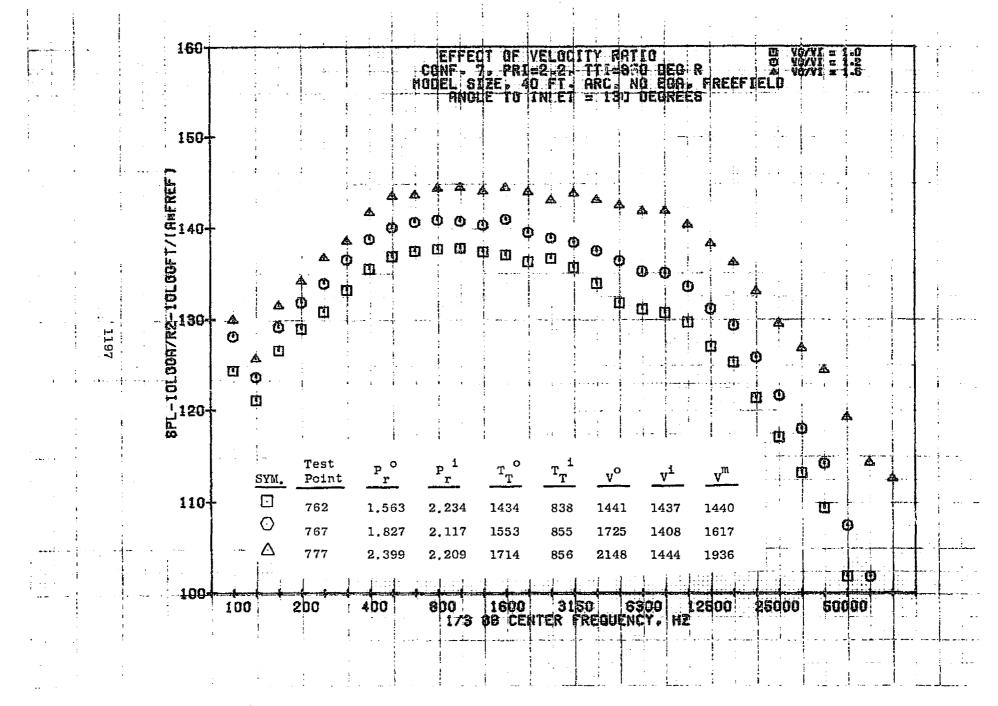
79 BURCH G.

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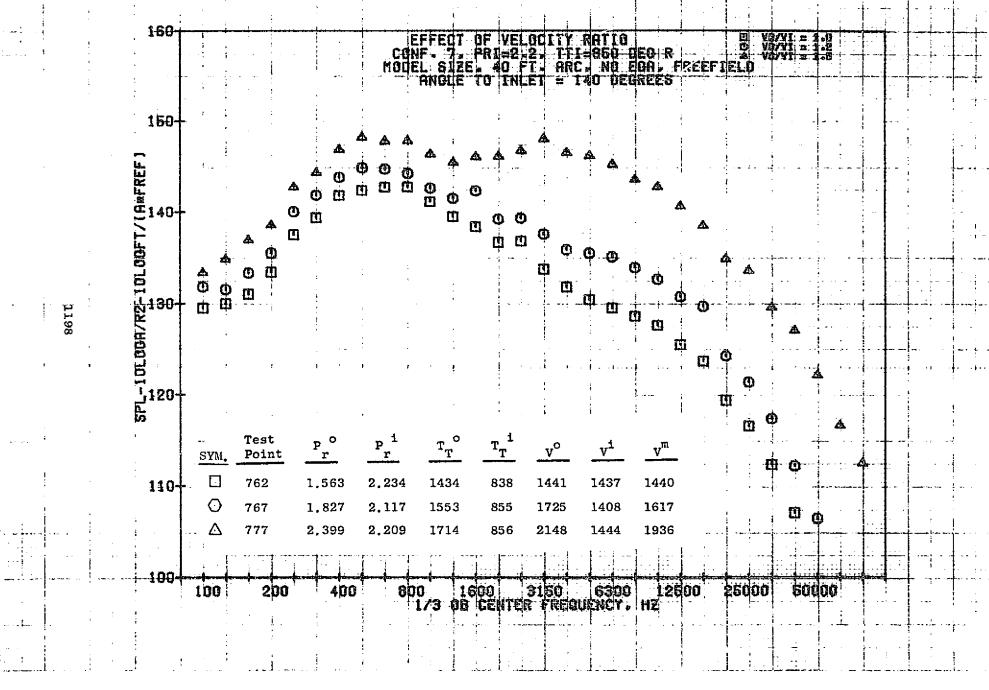
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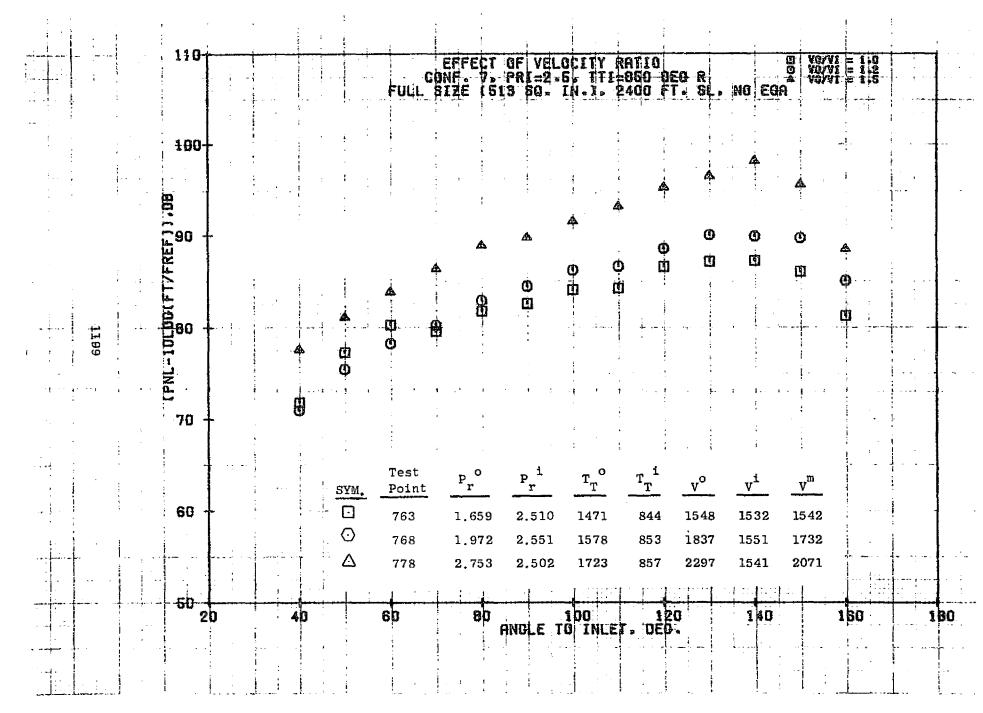
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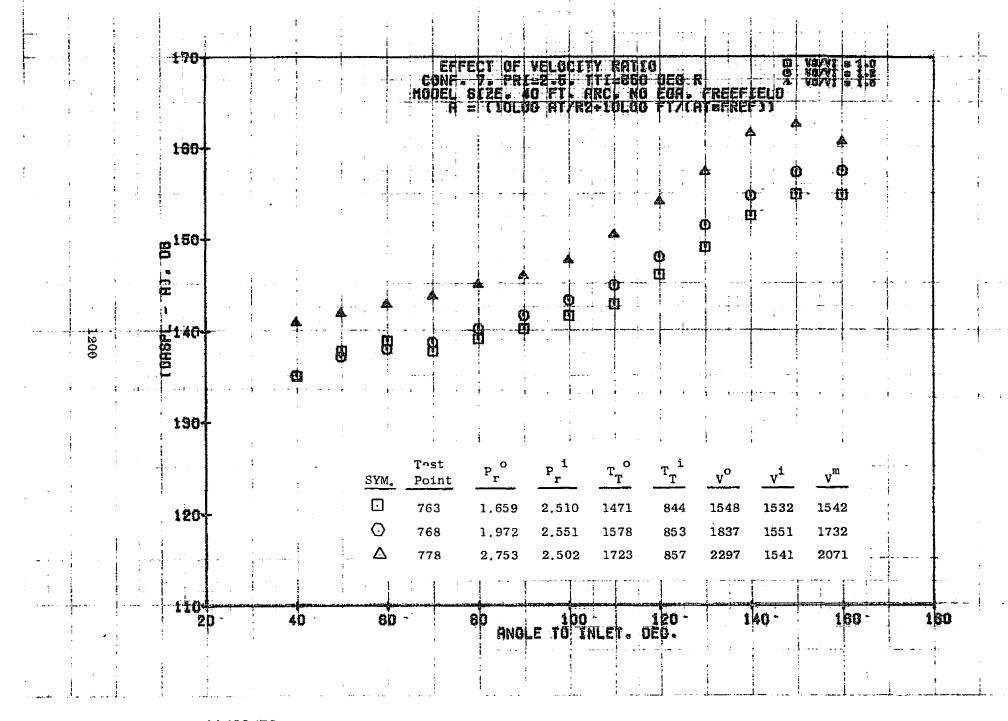


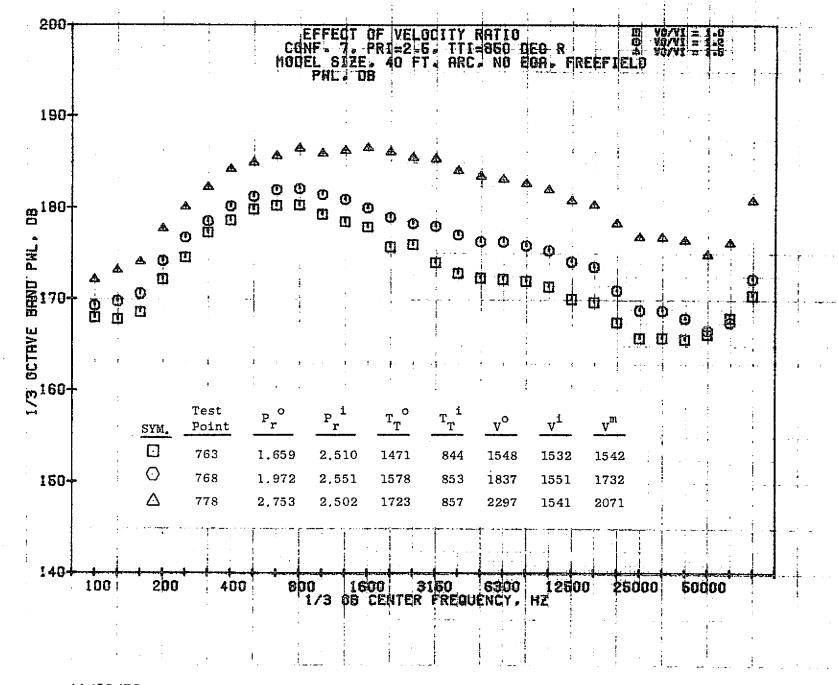


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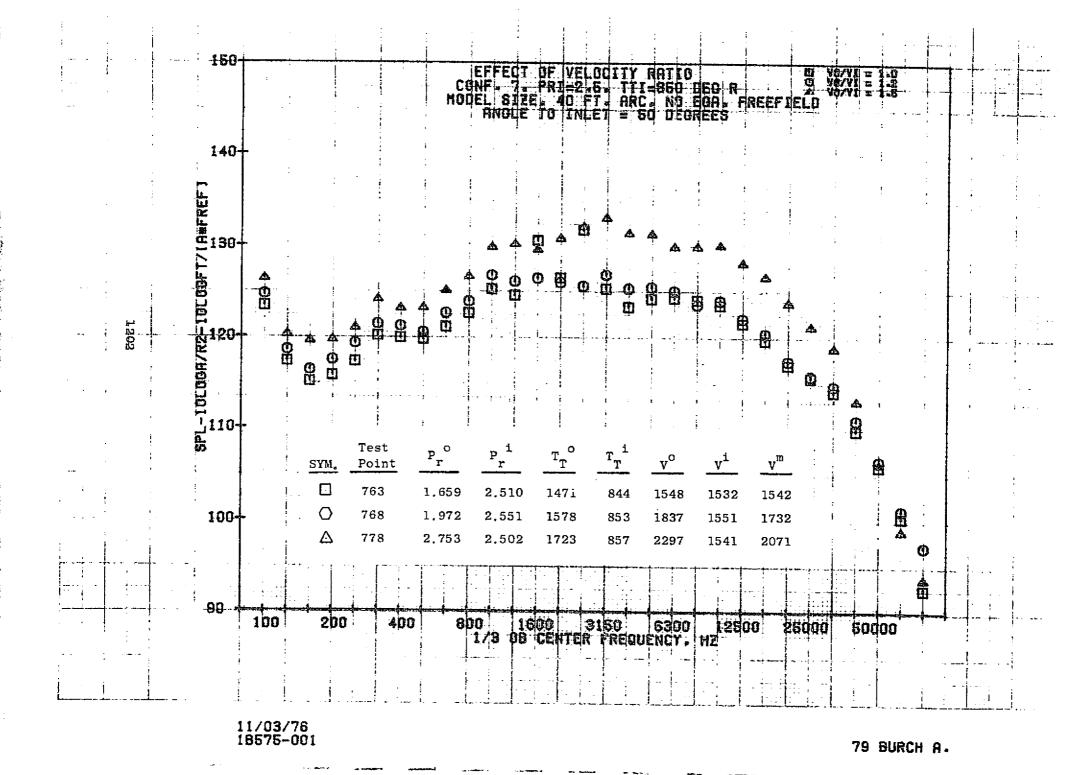
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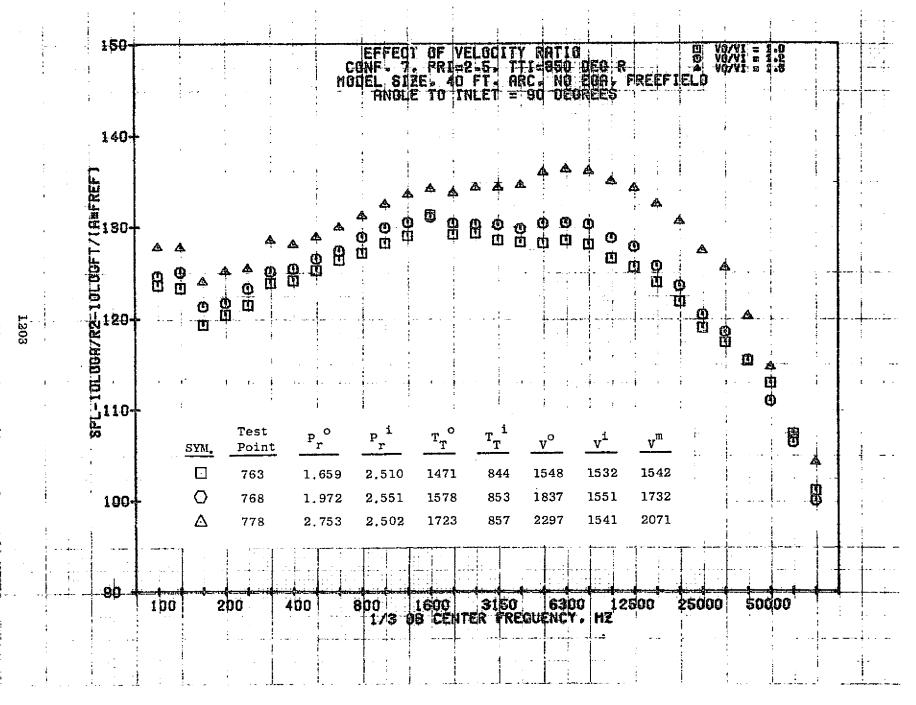


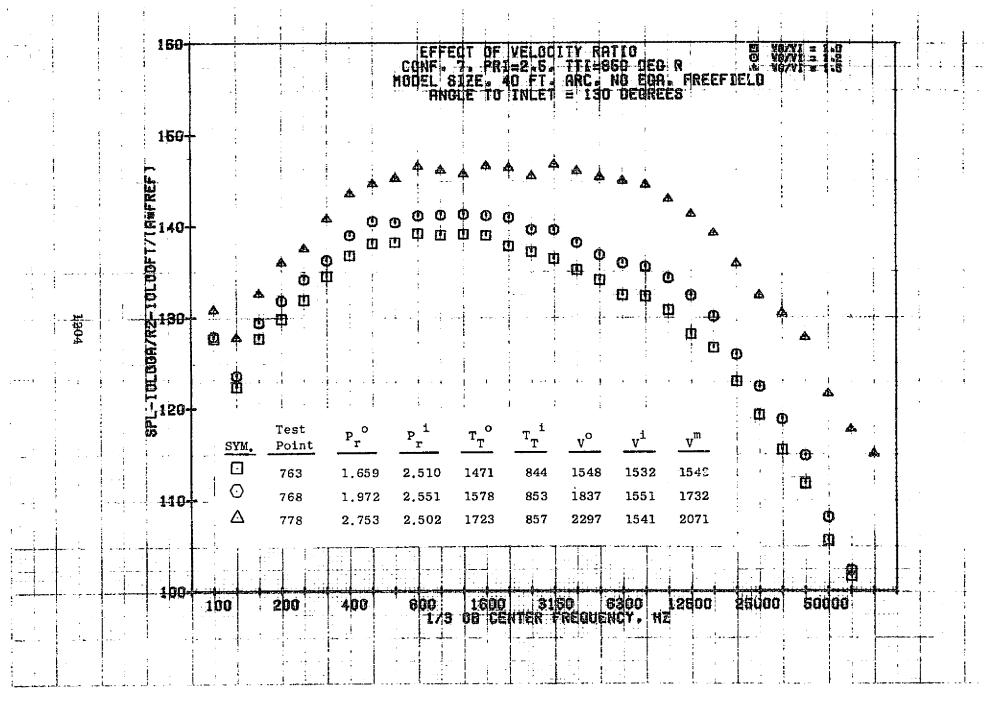


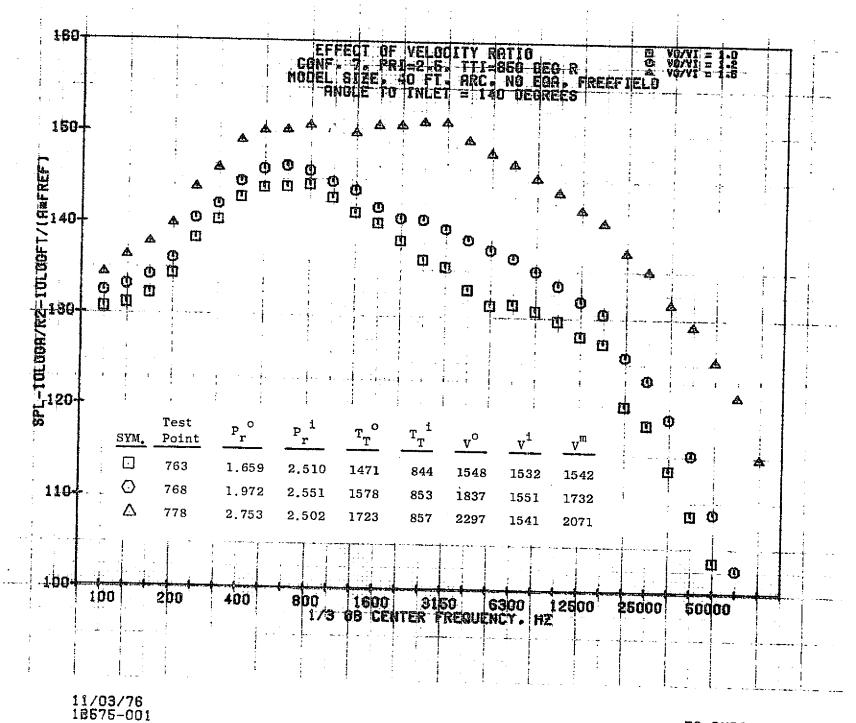
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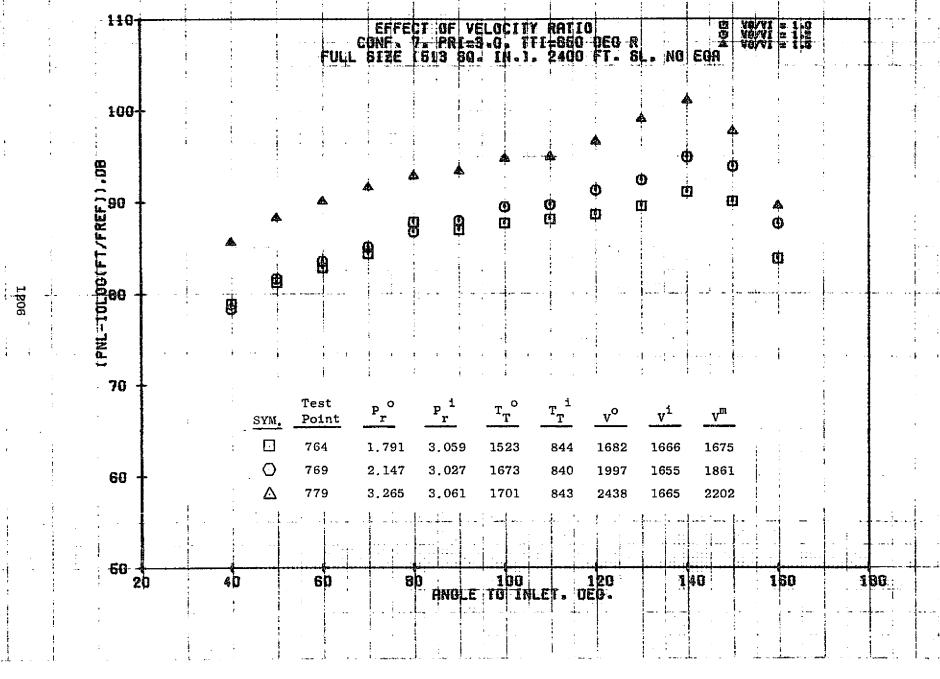




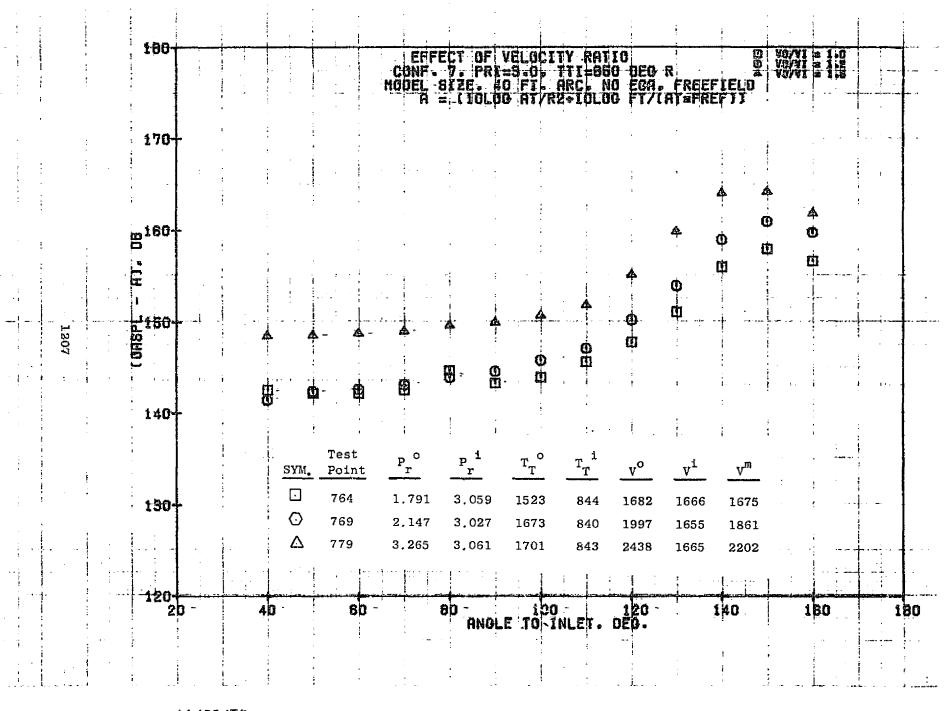




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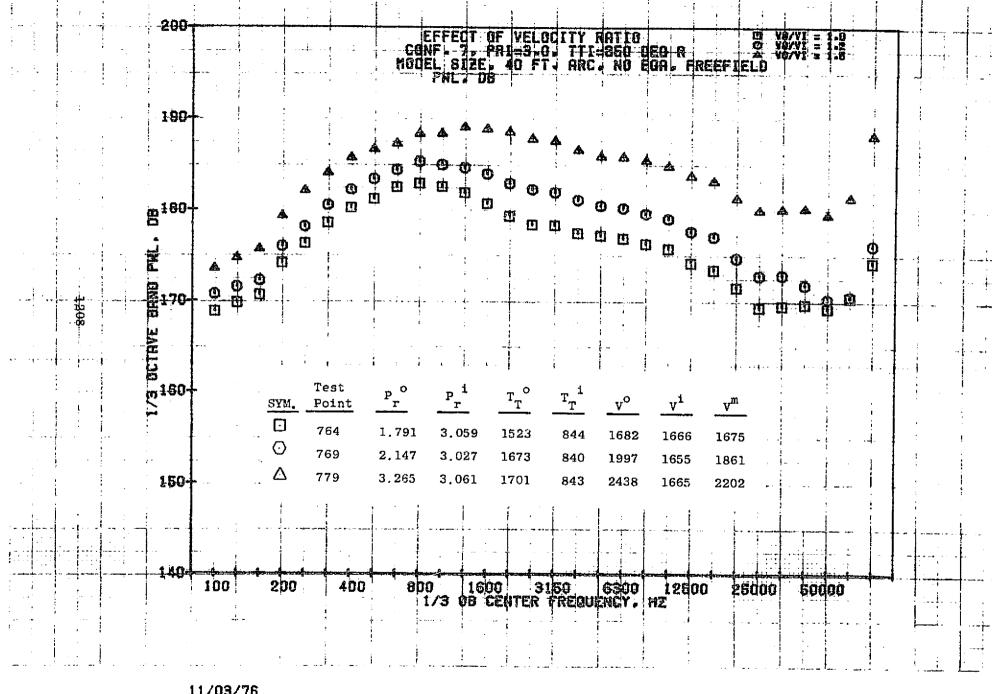
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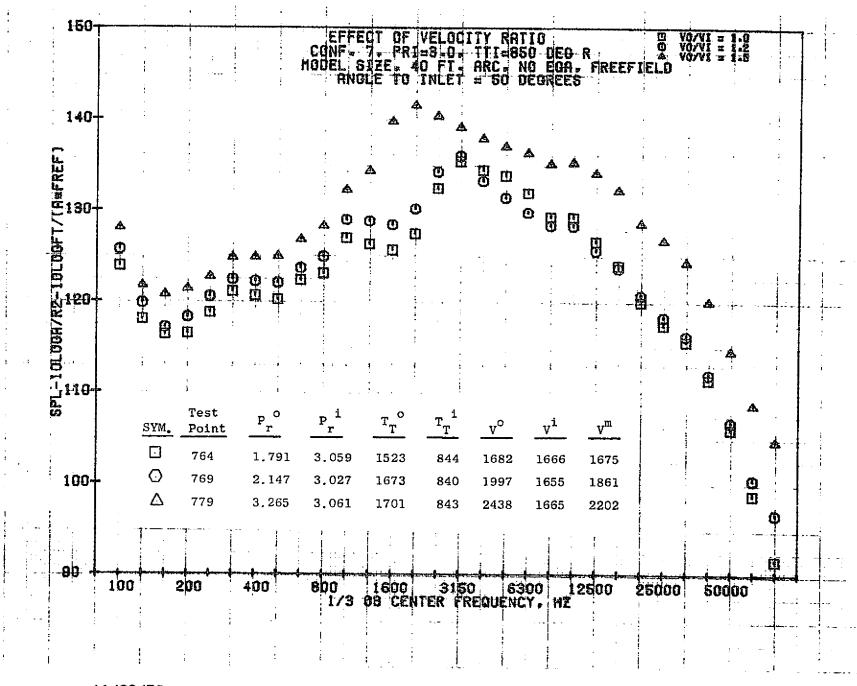


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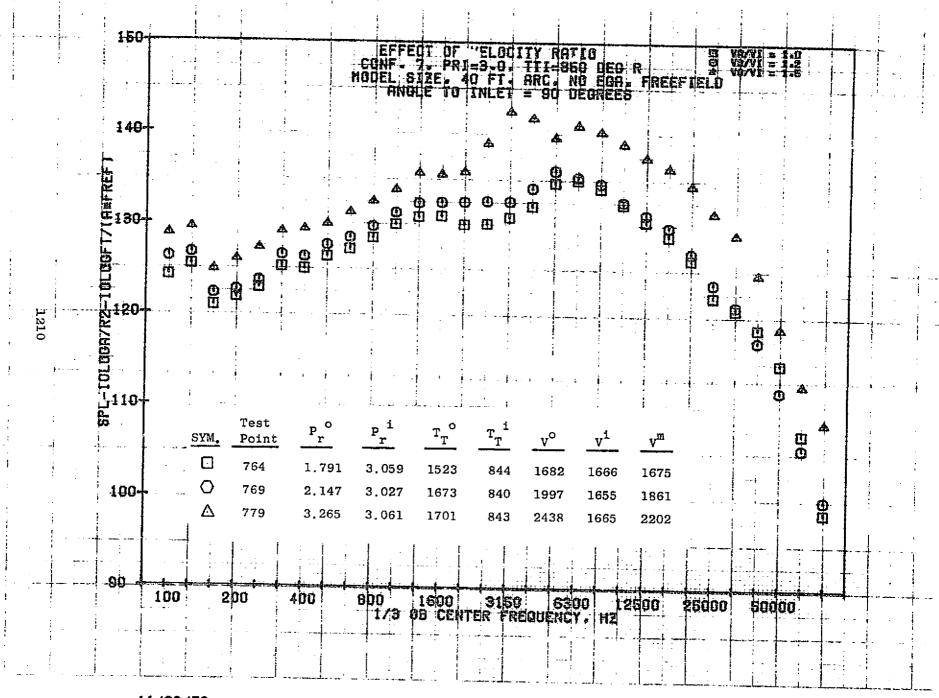
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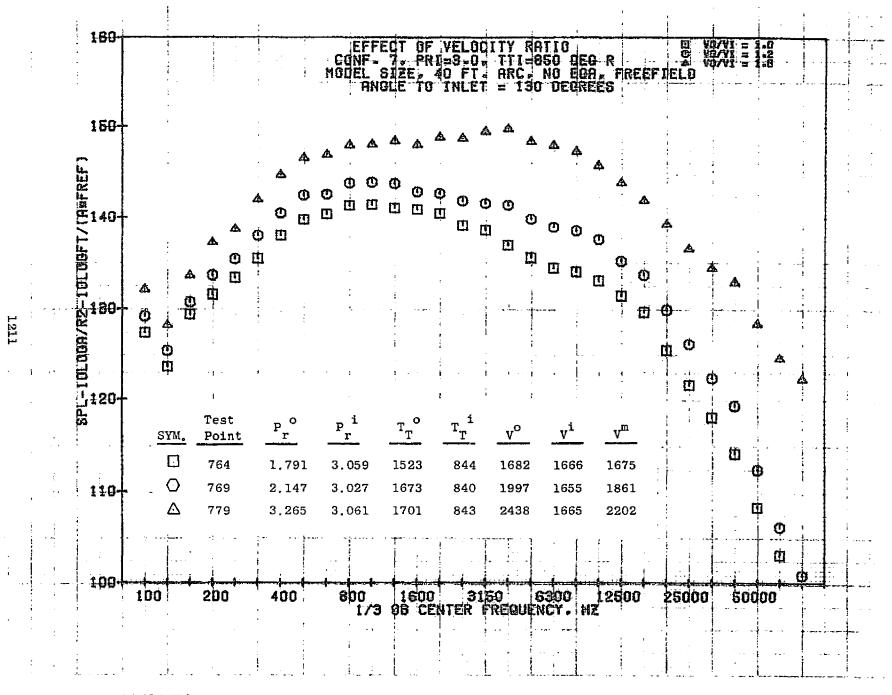
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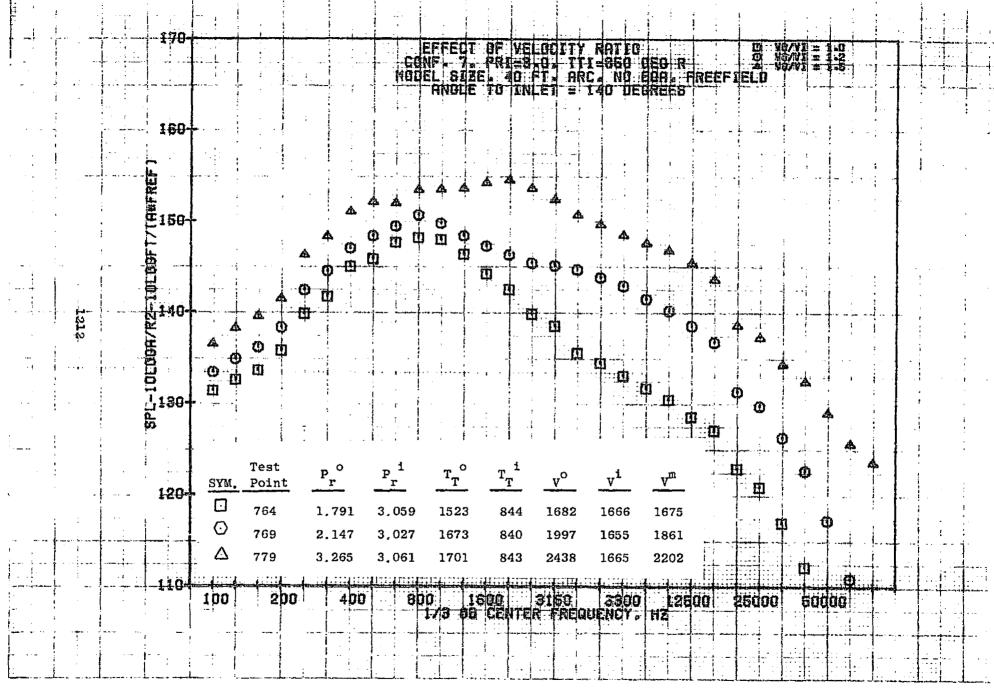




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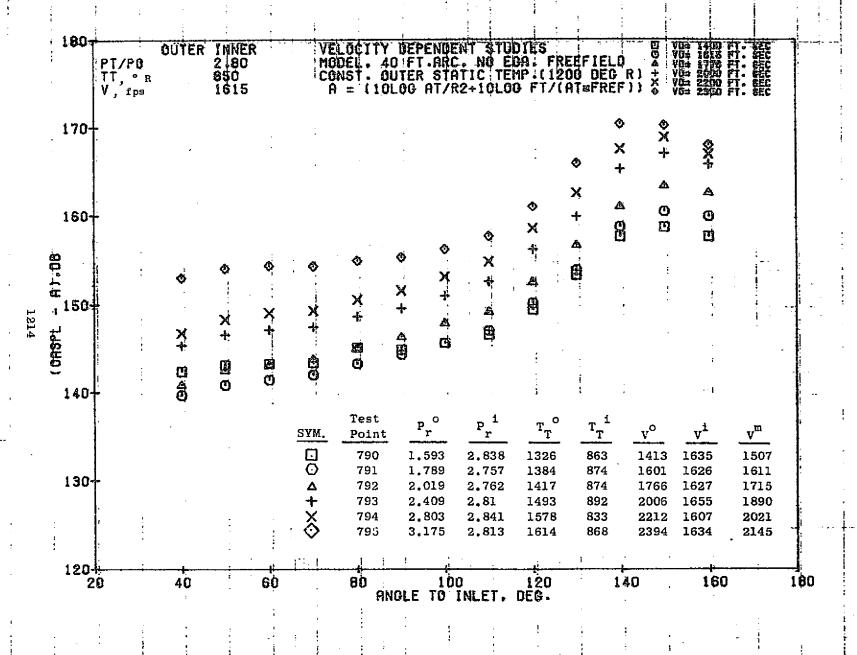






7.4.7 <u>Velocity Dependence Study</u>

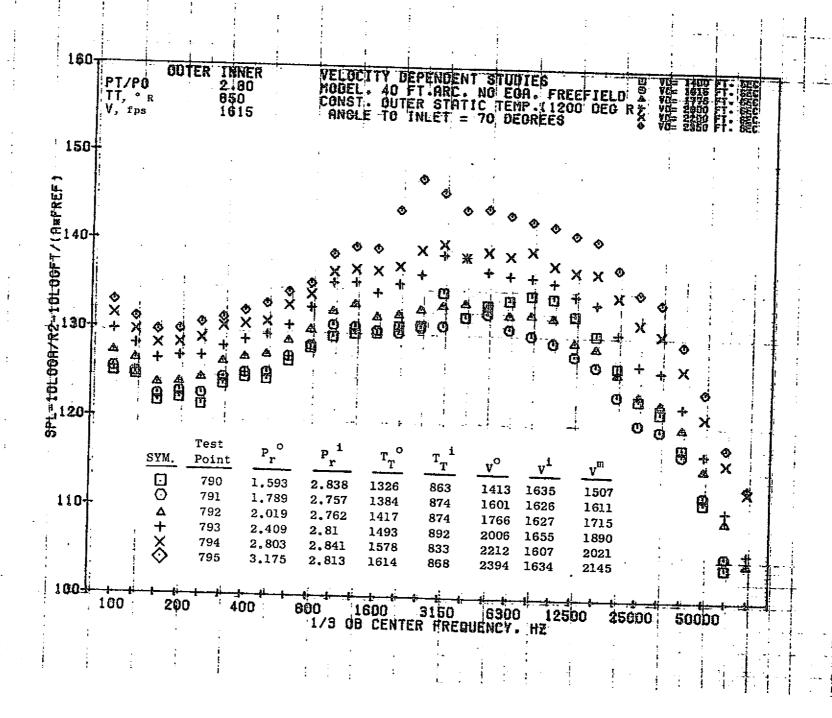
For Configuration 7, a series of tests was run to examine the velocity dependence of a high inner flow annular nozzle. Seven test points were taken at constant inner flow conditions and constant outer stream static temperature. The outer stream velocity was varied from point to point. The results are presented in this section.



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VELOCITY DEPENDENT STUDIES
MODEL. 40 FT.ARC. NO EGA. FREEFIELD
CONST. OUTER STATIC TEMP (1200 DEG F
ANGLE TO INLET = 110 DEGREES

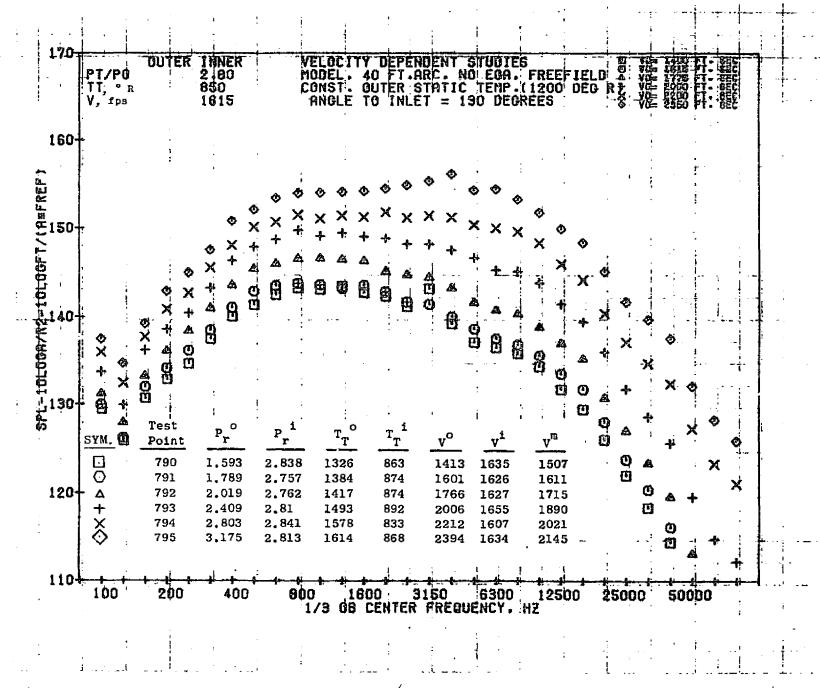
DOAFX

PREPRE

1.22

PT/PC TT, ° R V, fps INNER 2.80

OUTER



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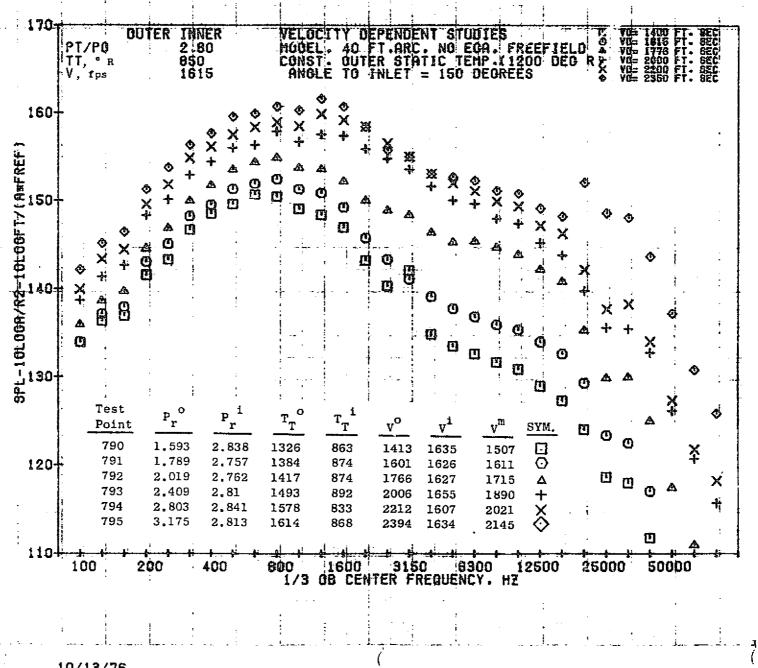
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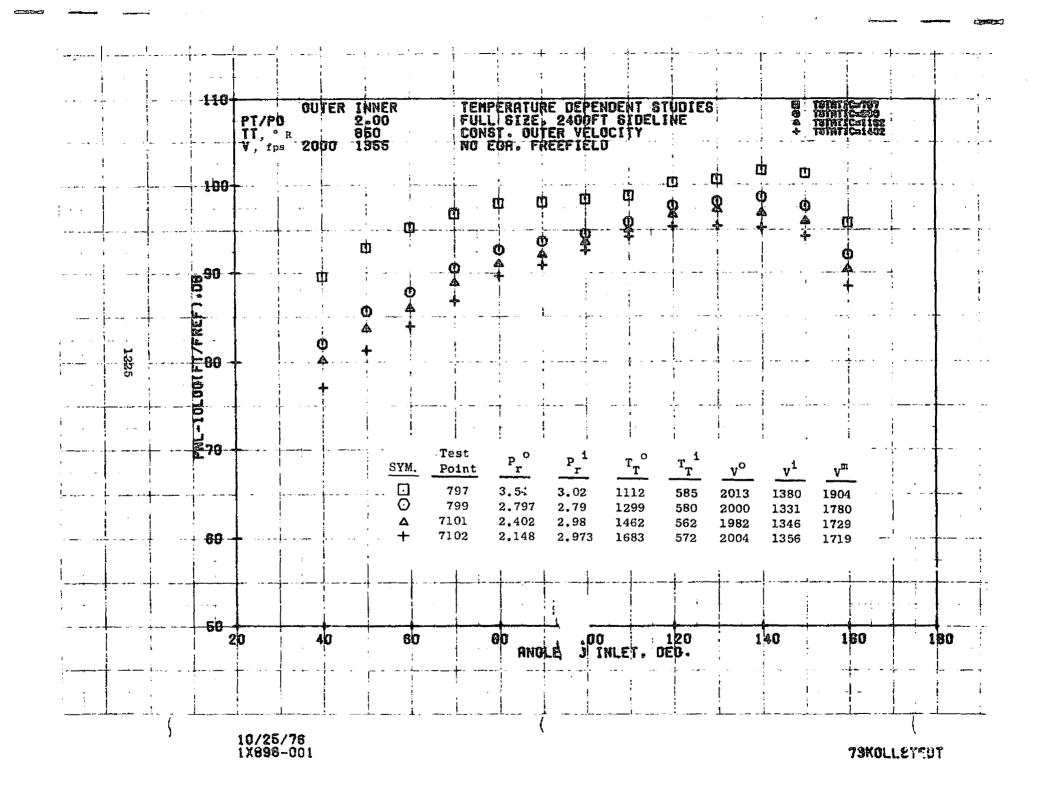
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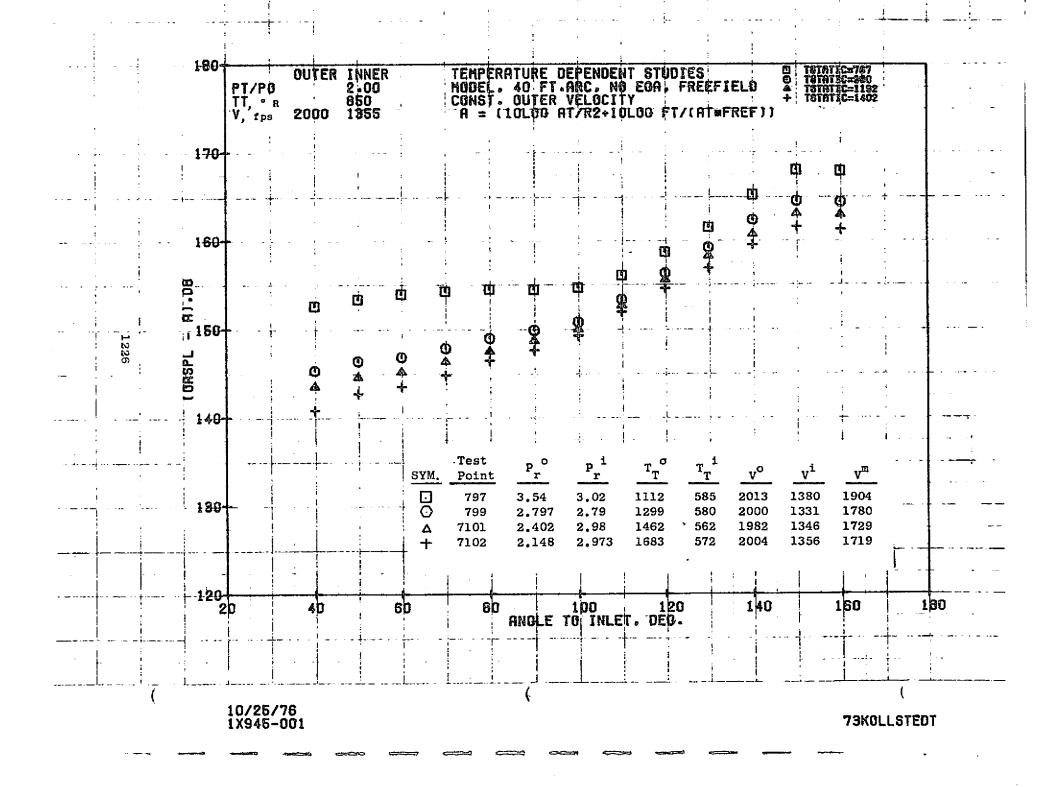
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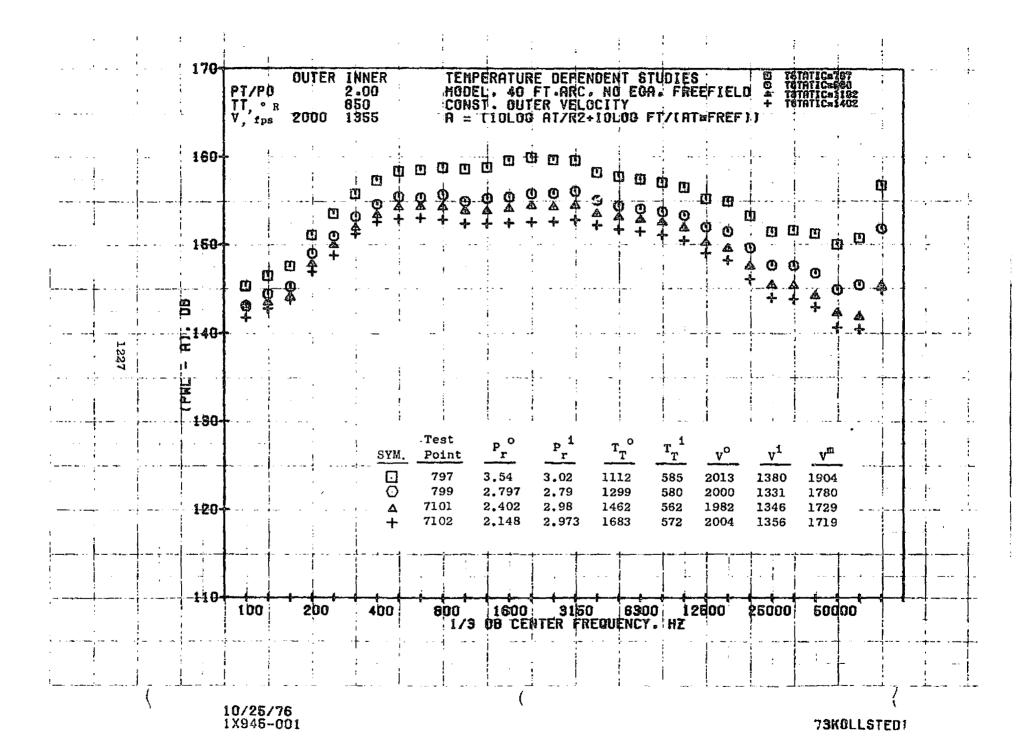
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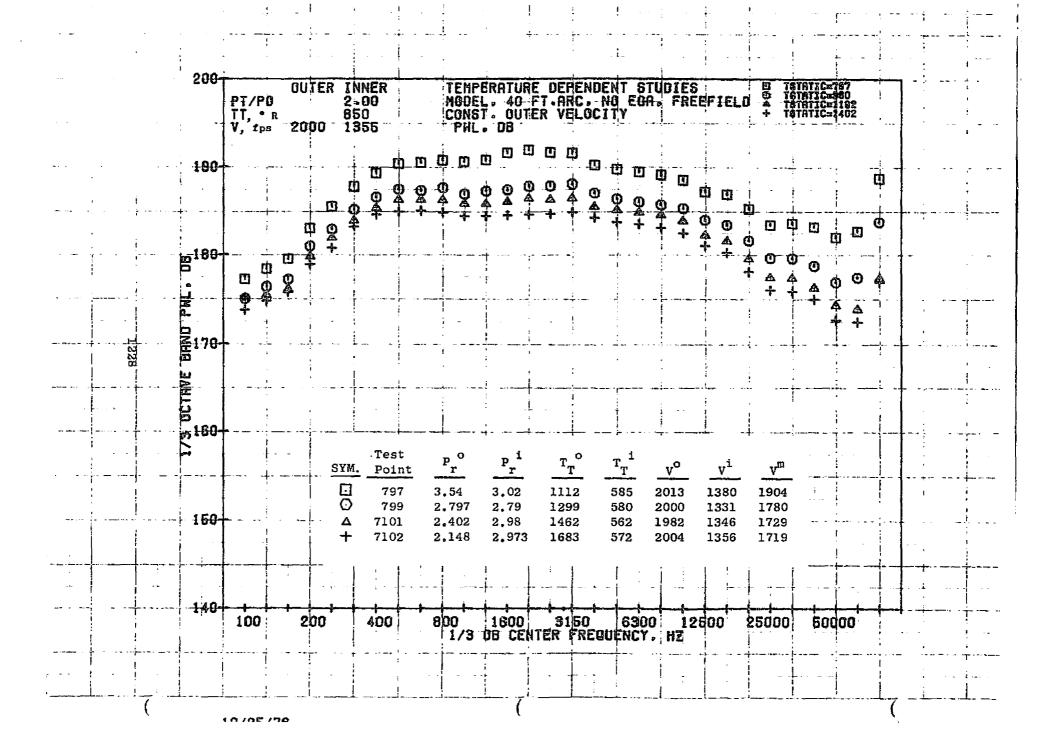
7.4.8 Temperature Dependence Study

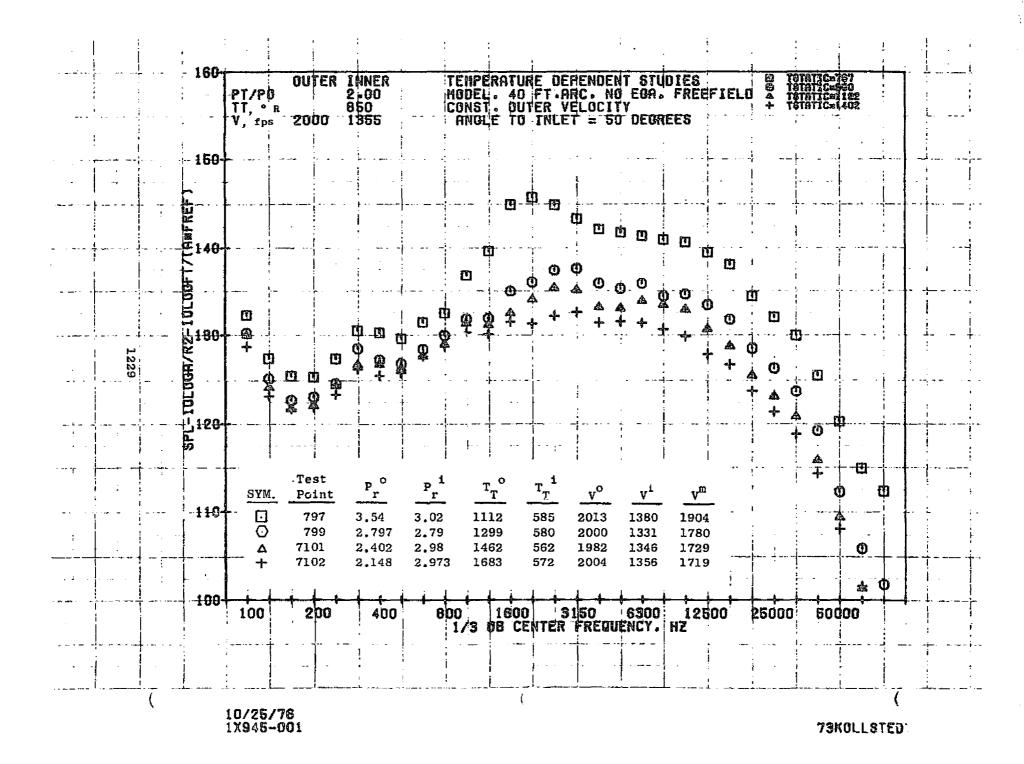
For Configuration 7, another series of tests was run to examine the temperature dependence of a high inner flow annular nozzle. For this study, the inner stream conditions were held constant, while the outer stream velocity was held constant and the static temperature of the outer stream was varied. The results are presented in this section.

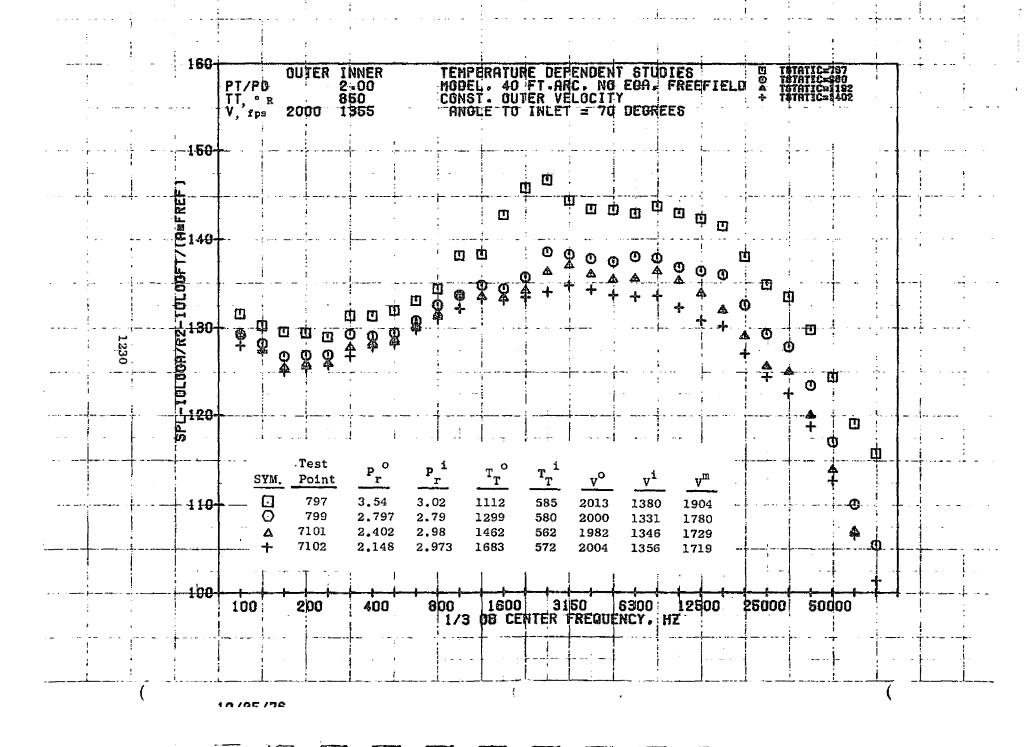


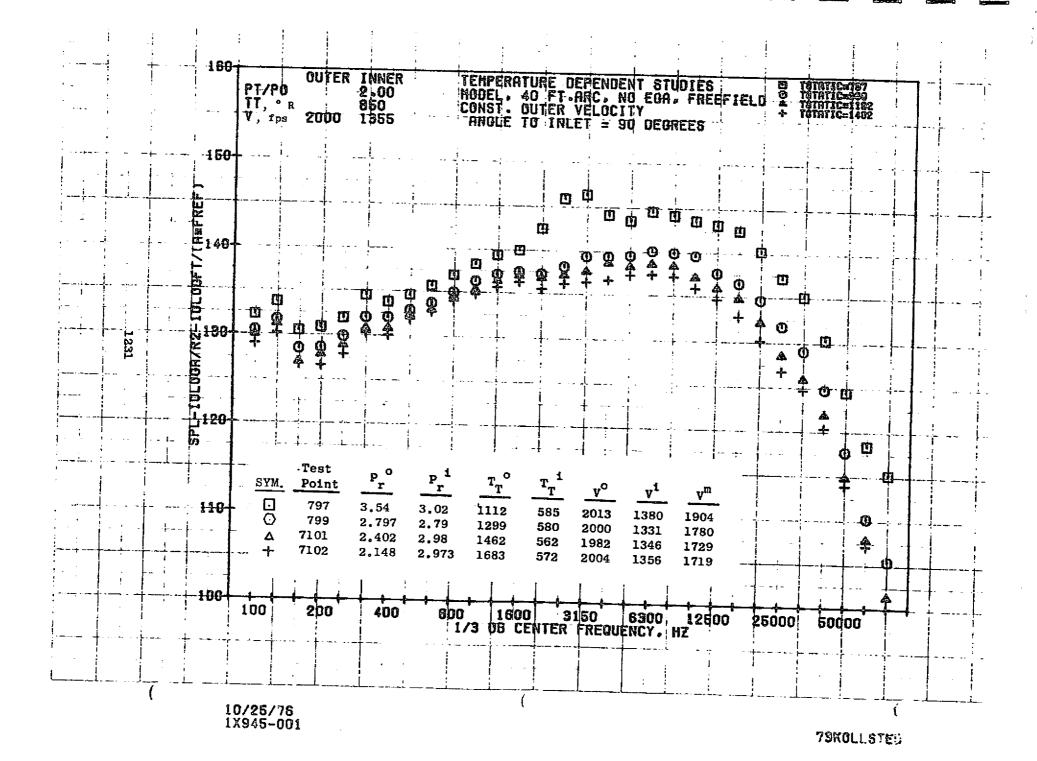


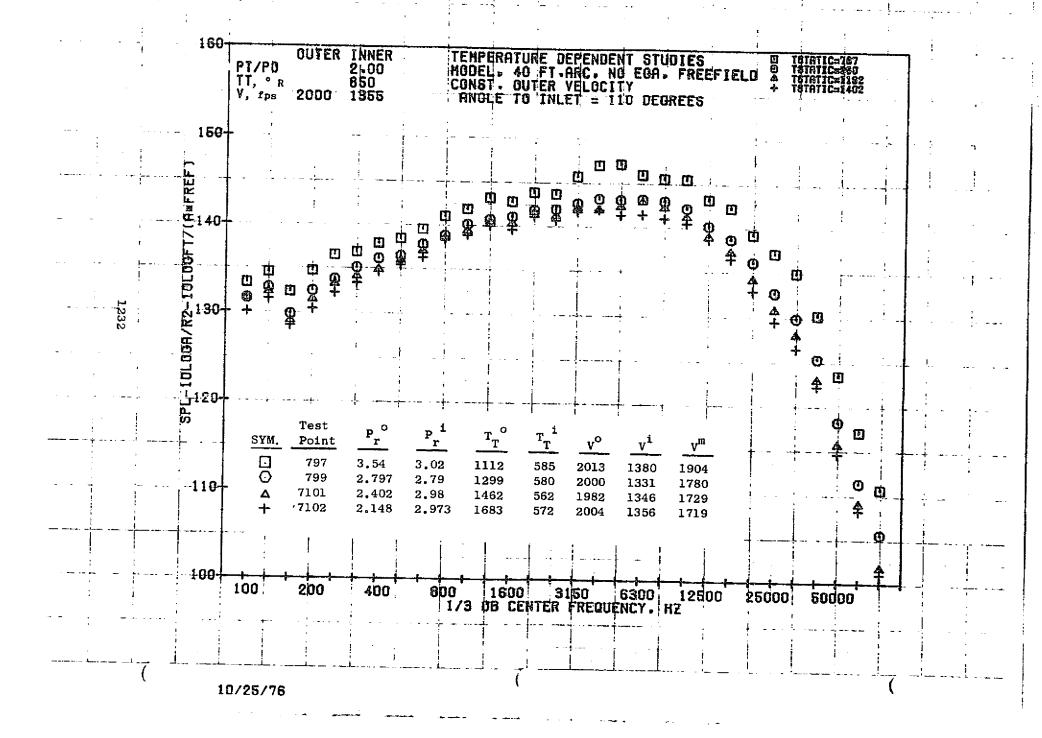


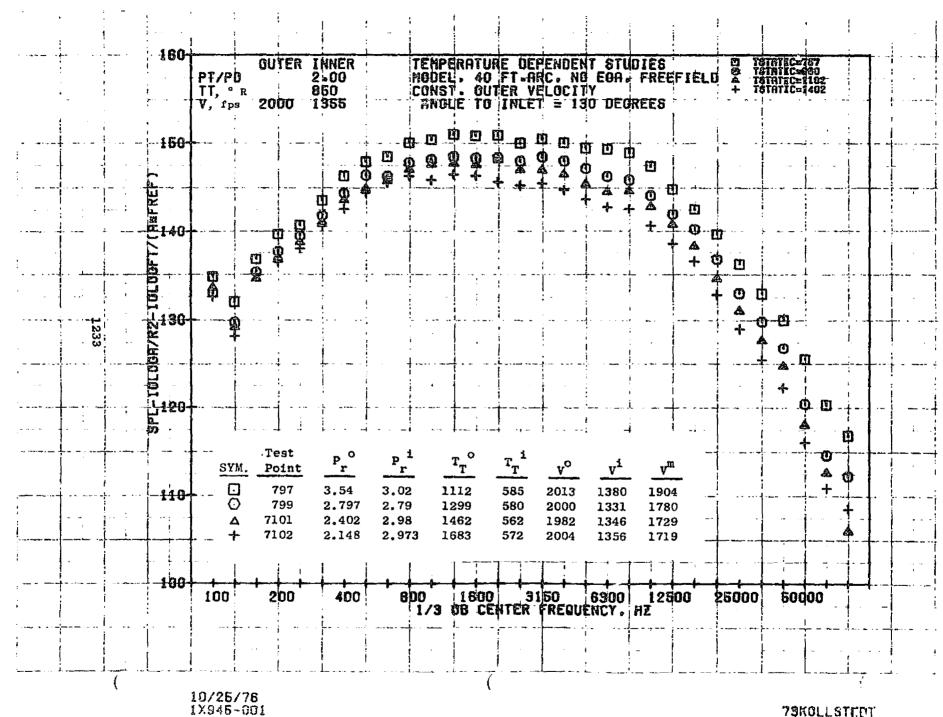












79KOLLSTEPT

